THE
ENGINEERING MAGAZINE
VOL. XV. SEPTEMBER, 1898. No. 6.

THE ESSENTIAL ELEMENTS OF MODERN SEA-POWER.

AN AUTHORITATIVE REVIEW OF ENGLAND'S NAVY AND SHIP-BUILDING PROGRAMME.

By Vice-Admiral P. H. Colomb, R. N.

A SIGNIFICANT feature of the times is the concentration of interest everywhere upon naval construction. The Spanish-American war has made clear the incalculable value of a strong navy in keeping peace—a function more important than that of establishing a victory. With England the question of naval power is always paramount, and to her navy is generally conceded mechanical, as well as military, preëminence; but some strong notes of alarm have been recently sounded in regard to the material condition of the British navy in comparison with the navies of France and Russia. The loudest, and strongest note, as can be immediately seen, is struck on the ground that it is fair criticism to leave out of the account the most numerous class of British war ships, the protected cruisers, which absorb more tonnage than any other class, except the battle-ships. The principal claim is to make an enormous addition to the battle-ships and to the armoured cruisers, and the assumption behind it is that England is bound to adopt a ship for-ship policy, ignoring strategical and tactical considerations. We should, in fact, count noses, as if the future rule of war will be that the whole of our fleet, and the whole of the fleets of France and Russia, will proceed into mid-Atlantic and there fight it out, class against class and ship against ship. I think it is quite time that that system of criticism should be dropped. It may be proper, when our navy has been allowed to fall behind by neglect, to carry out a ship-for-ship policy until a level has been reached; but then, considering that the classes, and proportionate classes, built by one power, are not necessarily those which meet the

Copyright, 1898, by John R. Dunlap.

wants of another power, we should carefully study the general strategical and tactical conditions, and build accordingly. Our idea would be "to develop the accepted principles which should appear in the formation of a really powerful navy."

The admitted final aim of our naval policy is to maintain a force which will match the navies of France and Russia, or any pair of the strongest naval powers that may be combined against us in war. The actual result is that we aim at somewhat overmatching any two such powers; and, before we can aver that the admiralty is lax in any particular, we must have some idea of what the whole force on each side is. Then, by considering some of the principal strategic and tactical conditions under which we must fight, if we fight at all, we shall ascertain how far the ships we are possessed of will be available, and therefore what will be our real comparative force, should war break out.

Though the Return No. 206, of May 17, 1898, is not as complete as could be wished, we must found ourselves upon it, as it must be taken to represent the admiralty case. The classes of ships dealt with in the return are battle-ships, cruisers, coast-defence vessels, special vessels, and torpedo craft. We must, I consider, never lose sight of the fact that there are only three strategic conditions under which our ships can be used: (1) where we operate in the enemy's waters; (2) where the enemy operates in our waters; (3) where the sea is left open to both sides, and at one point we are operating in the enemy's waters, while at another point he is operating in our waters,—or, in more technical language, where "the struggle for the command of the sea" is in full progress. It will not, I think, be contested that our hope and our aim must be to start with, and to maintain, the first condition; and the interest in the inquiry will be to discover whether or not we are now ready, and promise in future to be ready, to do so.

The return divides the whole of the forces into the two conditions —built and building. It is common, in drawing comparisons, to mix up the two conditions. Nothing could be more confusing. The one condition exhibits past policy, and the other present policy. The comparison, even when confined to ships built, must be faulty, because of the different conditions of readiness under which the ships are counted. But it seems a gratuitous introduction of confusion to count side by side a ship ready for sea and another ship whose keel is but half laid.

We may fairly leave out of the general account the coast-defence ships, on each side, because they cannot generally operate against one another. If we were operating in the enemy's waters, our coast-defence ships could be used only in exceptional cases, and, if the enemy

were operating in our waters, the like would happen to his coast-defence vessels. We can also leave out the special vessels, only one of them—the *Vesuvius*—being a fighting ship. The remaining ships built, then, naturally divide themselves into two groups, one of which bases its offensive power primarily on the gun, and the other primarily on the torpedo. We then get for the gun-ships the following:

Powers.	Nos.	Displacement.	
		Total Tons.	Average Tons.
Gt. Britain	181	1,122,408	6201
France	82	419,373	5114
Russia	28	205,833	7531
F & R	110	625,206	5683

Showing that, looked at in this general way, Great Britain has 64 per cent. in the numbers of her gun-ships, and 79 per cent. in their displacement, more than the combined possession of the two powers. But, as the displacement of our ships is so much greater, an allowance in numbers must be made in fairness, and that gives us the equivalent of 197 gun-ships to their 110, or 79 per cent. more.

The torpedo craft stand thus in the total:

Powers.	Nos.	Displacement.	
		Total Tons.	Average Tons.
Gt. Britain	183	49,792	272
France	224	27,620	123
Russia	135	25,987	191
F & R	359	53,607	150

Our past policy is exhibited here, for we show a deficiency both in numbers and displacement, due entirely to our ceasing to build torpedo-boats, and building instead torpedo-vessels and destroyers.

I am not going into the question either of speed or of coal endurance. It is common to claim that, if two ships come into action, or if two squadrons come into action, equal in all respects except in speed, then the slower ship or squadron is at a disadvantage. It is by no means generally true. Tactically, reduction of speed is advantageous in as many cases as is increase. Strategically, the higher speed is generally an advantage, but, as will be explained, it does not so much affect the strategy that we must adopt in war with France and Russia. In the same way, coal endurance, of no importance in tactics, but of great importance in strategy, does not so much affect the strategy we must adopt, where the coal will continually follow up the ships.

Reviewing our policy in this general way, we see that our aim is to have a greater number of larger gun-ships, but that we do not prepare for defending our own waters by torpedo-boats. France and Russia, looking on the torpedo-boat as the best defence of their home waters, where they expect to be attacked, keep a large stock.

We pass now to the gun-armament of the gun-ships, dividing it into heavy, to include the 7-inch and all guns of larger calibre; medium, to include all guns from 4-inch to 7-inch; and light, to include all other guns.

The following table summarises the comparative numbers and calibre of the heavy and medium guns in the gun-ships of Great-Britain, France, and Russia:

Powers.	Nos.	Calibre.	
		Total Inches.	Av'age Inches
Great Britain..	2229	14,707.24	6.60
France.....	927	6,011.80	6 48
Russia.....	337	2,411.60	7.15
F. & R.....	1264	8,423.40	6.66

This table shows us that our gun-ships carry 76 per cent. more heavy and medium guns than those of France and Russia combined. But, as the average calibre of our guns is somewhat less than that of the other powers, our numbers must be regarded as the equivalent of 2,208 guns, to their 1,264, or 74 per cent. more.

In light guns our gun-ships carry 3,335 guns to 2,031 carried by France and Russia, leaving us, therefore, superior by 64 per cent.

It is clear that, apart from any question of strategy, these ships, battle-ships, armoured cruisers, protected cruisers, and unprotected cruisers, form the bulk of the fighting forces on each side; and, if the figures are reasonably correct, we have, on the surface at least, a very large preponderance of force.

Turning to the torpedo craft, we find on our side 70 medium guns, averaging 4.72 inches' calibre, while France and Russia show 26 medium and heavy guns of 6.69 inches' calibre, leaving a margin of 23 guns on our side. In light guns we show about 796 guns to their 911. Perhaps our superiority in one kind of guns may be held to balance the deficiency in the other.

The torpedo-tubes on our side, in the torpedo craft, count about 583, while France and Russia have about 710. But torpedoes do not count much as weapons among torpedo craft. It depends entirely on the strategical view taken whether the deficiency is real.

No doubt this way of looking at the whole of the navies in bulk will be objected to. I submit that we cannot get a true view, unless

we at least begin in that way. Those who consider it a mistaken method are bound, I think, to show how it is to come about that only class will fight against class, in the face of the experience of the two latest steam wars, our only practical sources of information as to the present conditions in action.

Descending to particulars, we may consider the battle-ships and armoured and protected cruisers separately, omitting the unprotected cruisers. For the battle-ships we get this table:

Powers.	Nos.	Displacement.	
		Total Tons.	Average Tons
Gt. Britain	52	549,360	10.564
France	27	226,760	8,398
Russia	12	117,240	9,770
F & R.	39	344,000	8,820

That gives us 34 per cent. superiority in numbers; but, as our ships are so much larger, our real superiority is 62 ships, or 58 per cent.

The heavy and medium gun armaments of the battle-ships stand as follows:

Powers.	Nos.	Calibre.	
		Total Inches.	Av'age Inches
Gt. Britain	654	5145.00	8.02
France	353	2634.10	7.45
Russia	146	1206 80	8.26
F & R.	499	3840.90	7.69

This gives us a preponderance of 31 per cent., but, on account of the larger calibre of the guns, the equivalent is 32 per cent. In light guns the numbers are: Great Britain, 1,451; France and Russia, 1,000,—a preponderance on our side of 45 per cent.

The armoured and protected cruisers stand thus, in number and displacement:

Powers.	Nos.	Displacement.	
		Total Tons.	Average Tons
Gt. Britain	113	528,830	4679
France	39	144,804	3712
Russia	13	80,193	6168
F & R.	52	224,997	4326

This gives us a preponderance of 117 per cent. over France and Russia; but, as our ships are larger, the real preponderance is 122 per cent.

The heavy and medium gun-armaments stand thus:

Powers.	Nos.	Calibre.	
		Total Inches.	Av'age Inches
Gt. Britain	1224	7242.92	5.91
France	333	1933.70	5.80
Russia	180	1138.80	6.32
F & R	513	3072.50	5.98

This gives Great Britain a preponderance of 138 per cent., but, the calibre being a little less, her real preponderance is 134 per cent. In light guns the numbers are: Great Britain, 1,707; France and Russia, 845,—a preponderance on our side of 102 per cent.

Now we are in a position to consider what deductions may appear to diminish the great preponderance that the figures everywhere show on our side, except in defensive torpedo-craft and their armament. It is the practice in making comparisons to strike off altogether from our side considerable numbers of the battle-ships and of the armoured cruisers, on the plea that the patterns are obsolete, and many of the guns muzzle-loading. Now, as I have observed, the practice is extended to striking off the whole of the protected cruisers. It may be said once for all, on this latter point, that there is no justification for so acting. The admiralty policy of counting armoured and protected cruisers as one body is clear. The admiralty have evidently held for a long course of years that a protected cruiser, equal in all respects except in the disposition of her armour, is a fighting match for the armoured cruiser. We have deliberately built protected cruisers as the answer to armoured cruisers; and we have only just entered on the policy of building cruisers with belt armour, with the special idea of their fighting battle-ships.

It is, however, quite legitimate to declare that old-pattern ships and old-pattern guns cannot be put on an equality with the newest ships and the newest guns. But it is only after we have seen what nominal preponderance we are dealing with that we are in a position to apply a reasonable discount. To ignore altogether many ships and many guns is to assert that such ships and guns will not be sent to sea, even in the most pressing emergency of war,—a thing which cannot be reasonably asserted.

If we struck out altogether the 23 second- and third-class battle-ships, for instance, we should still be left with 29 of the most approved type, averaging 12,996 tons' displacement, carrying 401 guns of 7.84 inches' calibre, on an average, against France and Russia's total of 39 ships, averaging 8,820 tons, and carrying 499 guns

averaging 7.69 inches' calibre. Allowing for excess in displacement and calibre, we show an equivalent of 42 ships carrying 409 heavy and medium guns, which leaves us a preponderance in ships, and a deficit of only 19 per cent. in guns. But the displacement of the 23 second- and third-class cruisers allows us to add 18 ships to the preponderance of 3 that we have already shown. And then, taking only the breech-loading guns carried in the inferior battle-ships, we show the equivalent of 106 guns, to add to the 409 guns given above, making 515 guns to France and Russia's 499. Looked at from this point of view, we must say that the whole of the inferior battle-ships, and the whole of the muzzle-loading guns, can be treated only as preponderating margin, if the battle-fleets of Great Britain and of France and Russia are to be compared. The muzzle-loading guns in the inferior battle-ships number 135, averaging 10.05 inches' calibre.

I have already dwelt on the impossibility of admitting that armoured cruisers can properly be counted as apart from protected cruisers. The admiralty policy on this head is too plain. With us, taking armoured and protected cruisers together, we find 84 per cent. protected; with France, 76 per cent. are protected; with Russia, only 23 per cent. Perhaps 9 of the British armoured, and perhaps 11 of the British protected, cruisers are of inferior type; and, of their guns, 166, averaging 7.92 inches' calibre, are muzzle-loaders. But the points cannot be laboured when we are dealing with a preponderance on our side of about 70 ships and 659 guns.

The real question now at issue is whether the method I have adopted is a sound one. I am bound to say that, in any case, it is sounder than that sometimes adopted, where, the object being to prove inferiority on our side, whole classes are omitted, and others, such as battle-ships, armoured cruisers, and coast-defence ships, are grouped together as if there were some connection between them, when there is absolutely none. It is seen that, basing myself on what has taken place in the Chino-Japanese and Spanish-American wars, the old conception—which I used to hold as strongly as any one—that only battle-ships can fight battle-ships has passed away. There does not seem any doubt that all battle-fleets will, if the necessity arises, be supplemented by armoured or protected cruisers which will take their places in any battle-formation that may be adopted. But, while I think we must look at navies in this general way, my method does not show us to be inferior, even if it should be admitted that the heavy cruisers will not play a part in a general action.

Space forbids me to give a full account of the results arising out of the method I adopt, but, having adopted it, I must now briefly show what I conceive our strategy must be in a war with France and

Russia, and how our forces may be expected to work into it. I should like to say that I know of nothing to alter my strongly-expressed view that the torpedo-craft, as opposed to the gun-ship, is altering, and will still more alter, our views as to the battle-ship. It may be thought to be far-fetched, but I claim that the advance of the torpedo-craft has had a hand in producing the Cressy class of armoured battle-cruisers. Many months before the intention of building such ships was announced I had written it down that I was sure the next move would be to produce such ships; and by far the most important event of the Spanish-American war has been the production of the report of the United States board of survey on the wrecks of Cervera's squadron. The submission that "no torpedoes should be carried in fighting vessels"—that is, in gun-ships— will surely tend to separate gun and torpedo warfare; and the declaration that "rapid fire batteries in battle-ships are of supreme importance" is, to my mind, only another way of saying that the four very heavy guns which have come to be the one distinguishing feature of the battle-ships are not of that preponderating value which we have all set upon them.

I have suggested that, if war were to break out between ourselves and France and Russia combined, our aim would be to keep the war in the enemy's waters; evidently we can do that only by "masking" the forces of the enemy, wherever they are found, when war breaks out. With Russia, this can mean only that we should desire to block her ships in the Baltic and the Black sea, and in such of her war ports—as Vladivostock, and now Port Arthur—as exist abroad. As to France, we should desire to block her ships in their separate ports, as Cherbourg, Brest, L'Orient, Rochefort, and Toulon, and in ports abroad, such as Saigon and Diego Suarez. All French and Russian ships in neutral ports would be "shadowed," as has been the practice with Russian ships in all the Russian scares. We should aim at doing on a large scale with all the naval forces of France and Russia what the United States did with Cervera's squadron at Santiago.

Speaking generally, we might assume that at first we should make no attempt to pass into the Baltic or the Black Sea, as we should make no attempt to press into French ports, and as Sampson made no attempt to pass into the harbour of Santiago. The point still debated and unsettled is whether the heavy ships would be placed as watchers as well as maskers,—that is, close off the points of exit that would be used by the enemy,—or in the nearest convenient ports, as maskers only, not in actual touch with the enemy, leaving the watch to be done by light ships and torpedo-craft. I think the latter plan would be adopted, and its full success would depend on the nearness of the anchorage to the point of exit, and the sufficiency and efficiency of

the light watching squadrons. It is evident, I think, that, by treaty and alliance with the northern powers, we should acquire the right to use the more convenient anchorages at the entrance to the Sound and the Belts, and here we might place our heavy ships. A glance at the chart shows that it could be made perfectly hopeless for the Russians to get to sea without being brought to action; and, if our masking force were only somewhat superior, there could be no motive for the Russian fleet to attempt to pass to sea. The fate of Cervera's squadron will leave its mark here, for the Russian admirals would be quite aware that, whatever motive there was for putting to sea, it could not exist after the battle, however the battle might terminate. The chart assures us that the widest of the three passages available for the Russian ships is only three miles across.

It becomes evident that neither speed or coal endurance would have to be considered in selecting ships to bar these passages; it has been generally understood that even our coast-defence ships would have gone to the Baltic, if necessary, had Russian scares developed into war. I cannot doubt but that these would still take part in blocking the channels mentioned, and that, so long as we did not propose to pass into the Baltic, the guarding of these passages might be safely confided to a sufficient number of the so-called obsolete battleships and armoured cruisers. These ships themselves would undertake the watch, and the light ships and torpedo-craft would be left available for duty elsewhere. I take it that the British heavy ships masking the French northern ports would be found perhaps at Dover, and at Portsmouth, Portland, and Plymouth; while the lighter cruisers, the torpedo vessels, and the destroyers, would undertake to watch and to report in time to the parent masking fleets. There is almost a general understanding that, for the masking of Toulon, the fleet would be stationed at Gibraltar, and that then a sufficiency of light vessels and torpedo craft would watch, and report from, Toulon, if, under such conditions, we can assume French fleets putting to sea. But I own that I find great difficulty in supposing anything to tempt them, so long as the masking squadrons were superior. It is plain that escape would be attempted only by the ships having the highest speed and coal endurance. If they did succeed in evading, a like selection from the Gibraltar fleet would be left to deal with them.

Apart from treaties with Turkey, anchorage would be found in the vicinity of the Dardanelles, where the masking fleet might be stationed, either in direct watch upon the entrance, or leaving the watch to lighter vessels. The foreign ports would be left to be dealt with by our ships already in those waters,—reinforced if necessary.

Any one can see that our nominal margins of preponderance be-

come real, as soon as it is observed how the older classes can undertake the blocking of the Baltic, and then it is easy to show a sufficient preponderance in the rest of the masking fleets, even allotting cruisers for the protection of commerce against such ships of the enemy as escape the watch set upon them.

If I am right as to the general employment of our ships on the outbreak of war with France and Russia, and if I show that, even as we stand, we have sufficient forces for the purpose, a very few words will suffice to deal with the building programme, because it becomes necessary to show only that ours keeps pace with the programmes of France and Russia.

All these countries have agreed not to build more unprotected cruisers, coast-defence vessels, or special vessels. England and Russia have ceased to build torpedo-vessels, Russia never having shown affection for that class of ship, and France having so far forsaken the type that she is building only two. All these countries are building destroyers. England is building forty-six, and nearly doubling her stock, and France is beginning with eight where she had none before, while Russia is adding twenty-eight to the one she already possesses. Neither England or Russia is building torpedo-boats, but France is adding thirty-eight to her already large stock. On the other hand, all three countries are building battle-ships,—England twelve, France eight, and Russia six. It is not, therefore, unreasonable to suggest that we might lay down two more, to be on the safe side, unless we take into account that the average tonnage of our ships is 13,633 tons against the 12,179 of France and Russia, and unless we count the Cressy class as practically battle-ships. All three countries are building armoured cruisers,—England eight, France ten, and Russia one. All three countries are building protected cruisers,—England twenty-four, France ten, and Russia three. We are therefore building thirty-two cruisers against the twenty-four that France and Russia are building. We are maintaining our policy of having the larger number of larger ships, our armoured and protected cruisers averaging 7,485 tons, while those of France and Russia average 7,005 tons.

As a conclusion, I think we may say that there is nowhere in our ship-building policy and condition any cause for alarm. Without doubt we must continue to exercise vigilance and forethought, but I am as convinced as ever that this is exactly the wrong time for urging sensational programmes, especially in the matter of battle-ships and armoured cruisers. The Spanish-American war has left us just where we were in the matter of the value of torpedo-craft, but I hold it to be there, more than anywhere else, that we require to remain awake.

ENGINEERING LESSONS FROM THE HISPANO-AMERICAN WAR.

MECHANICAL SUPREMACY THE VITAL FACTOR IN NAVAL SUCCESS.

By Hiram Stevens Maxim.

IN the days of the Roman empire the implements of war were simple in the extreme, and the northern barbarian, with a few hours' training, often proved himself more than a match for the best Roman soldier. When the instruments of warfare were simple and easily understood, the rich and civilised nations had but little advantage over the poor and uncivilised tribes. The advent of gunpowder, however, brought into use an instrument of destruction much more complicated and difficult to understand than the old two-edged Roman sword. Moreover, the use of fire-arms required a higher degree of intelligence, and the manufacture of the arms and powder required both mechanical and chemical skill of no mean order. This was the first step which gave the civilised nations a decided advantage over an uncivilised foe. Moreover, guns and ammunition were found to be much more expensive than spears, swords, or bows and arrows. This again proved to be a great advantage to the civilised nations. With the old sword there was little chance of improvement; it was simply a piece of tempered steel provided with one or more edges, the length depending upon the taste of the nation employing it. But the gun, being a more complicated instrument, was susceptible of many improvements. The nation most skilful in the manufacture of iron and steel would naturally be possessed of the best fire-arms, and in all probability the great advance which Europe has made in the mechanical and engineering arts is due in no small measure to the competition in the development of fire-arms.

When the English and the Spaniards met three hundred years ago, it was found that the English ships, although small, were better built than the Spanish, and could outsail them. Moreover, the English sailors possessed greater skill than their enemies in the management of the ships, while the English gunners were superior at all points to their Spanish enemies. Nevertheless the Spaniards were able to inflict very heavy losses upon the English. The fights between the Spanish and the English in those days were not always one-sided affairs. The ships and guns employed were very primitive, and comparatively little skill was required for their management. Nevertheless the slight advantage in skill possessed by the English nearly always brought them victory.

In the olden time, when international commerce was almost unknown, it was generally necessary for each nation to manufacture

its own arms; thus the mechanical skill of a nation was a determining factor in warfare. At the present time, however, every nation or tribe, no matter how uncivilised, can purchase the best arms, if able to pay for them. If, for instance, to-day 10,000 Turks should meet 10,000 Frenchmen or Germans in the open field, it would be a toss-up as to which would win, with the odds, if anything, in favor of the Turks; but, if the Turks should employ only such instruments of warfare as they are able to make themselves, they would have absolutely no show against other European troops. But this relates only to arms comparatively easy to understand, such as rifles and field artillery. When, however, we come to the navy, which is distinctly several grades higher, we find that, no matter how perfectly a warship may be constructed, and no matter how accurately the arms may be made, the Turk is not sufficiently mechanical and technical to understand and take charge of them. He cannot even be taught the necessity of cleanliness and order; the engines and boilers are allowed to rust, and the hulls become covered with animal and vegetable growths, until the ship and its armament are comparatively worthless for the purposes for which they were constructed. If such a ship, manned and navigated by Turks, were to meet a French or German ship of equal size, the combat would be of short duration, as the Turkish ship would speedily be rendered *hors de combat.*

Sea-fighting has changed completely since the days of the Spanish Armada. It is also entirely different from what it was in the days of Nelson. Instead of the wooden ships of the olden time, armed with cast-iron or bronze smooth bores using spherical ammunition, we have the modern cruiser and battleship. It is said that the Oregon, which may be considered one of the best types of modern battleships, is provided with about 100 steam engines, used for different purposes. Moreover, there is an extensive electrical plant. The manufacture of the vast and intricate machinery that one finds on a battleship of this kind requires an immense amount of skill, and the intelligent operation and care thereof require almost as much more. It does not require much skill to manipulate light projectiles, but it evidently requires a high order of skill to understand and work apparatus for moving heavy projectiles and charges by means of steam or electricity.

The Spaniards were able to purchase some of the best cruisers in the world. They were also able to provide themselves with a considerable number of torpedo boats and torpedo-boat destroyers. Several of these were made in England. The machinery in them was of the highest order known to modern steam engineers. The Spaniards were also able to purchase excellent guns and ammunition. The Americans, on the other hand, built their own ships and made their

own guns, and the very fact that they were obliged to do this gave them the necessary skill in their management afterwards. Five or six large cruisers which Spain had at the beginning of the war were supposed to make from twenty to twenty-one knots per hour. Now, in order to make this speed, it was necessary that the hulls should be clean and smooth, that the boilers and grates should be clean, that the coal should be of good quality, and that the engines should be of the highest degree of efficiency. Had these ships been in the hands of engineers such as may be found in England, the United States, or Germany, they doubtless would have developed a speed very nearly equal to that claimed for them. When, however, they were taken possession of by the Spanish engineers, everything apparently was neglected. The hulls were allowed to become foul, and the boilers to get completely out of order; the engines did not receive the proper care; the stokers did not possess sufficient skill to keep up the steam pressure; hence, instead of twenty to twenty-one knots, they could make but fourteen or fifteen.

It was expected that this powerful, swift fleet of armoured cruisers would do a great deal of damage to the American coast. It was claimed at the time that the Americans had but one ship which was their equal in both speed and armament,—namely, the New York. It was believed in Europe that the Spanish cruisers could run away from the American battleships, and outfight the American cruisers.

When I was in Paris at the beginning of hostilities, nearly everyone said that the Spaniards would have altogether the best of it for the first five or six months; that the American fleet would be practically annihilated; and that probably New York and Boston would be bombarded. When I expressed my opinion that in all probability no Spanish ship would get farther north than Cape Hatteras, they shrugged their shoulders, and said: "Very well, we shall see." I was assured by a number of Spanish sympathisers that the Spaniards would be sure to give a very good account of themselves. A great deal was said about the Cape Verde fleet. A great deal was also said about the torpedo-boat destroyers, and so forth. Some of the English papers, speaking of the Spanish fleet of torpedo boats, said it had caused perfect consternation in the American navy. It was said that the Americans would probably win in the long run, but that the United States was a much bigger target than Spain, and the Americans had begun to appreciate it; that the Americans stood a very poor chance against the highly-trained Spanish regulars, and the powerful cruisers with which Spain was so liberally provided.

Let us see now what actually took place.

The much-vaunted Cape Verde fleet at last sailed. This was sup-

posed to strike terror into the hearts of the Americans. Very little was heard of this fleet for a long time. Then we learned that only a few torpedo boats had succeeded in crossing the Atlantic. Next we heard that one of the destroyers was left at Porto Rico. And finally we found that the whole of Cervera's fleet had succeeded in entering Santiago harbour,—an event which was held up as marking a great and glorious day for Spain.

The next important event was the attempt of the Spaniards to escape. They had noticed that the Americans held religious services on Sunday morning; they believed that steam pressure would be low, on the American vessels, and that they might be caught napping; moreover, the swift New York, which they feared most of all, was ten miles away. This seemed an excellent opportunity to escape. It was said that the cruisers were able to go about five knots per hour faster than the American battleships, and it appeared to the Spaniards that they stood a very good chance to shew them a clean pair of heels with the exchange of but a few shots. When, however, they came out of harbour, it was found that only one of their ships, the "Cristobal Colon," was able to go faster than the American battleships, and they very soon found themselves paired off with American ships fast enough to be able to choose their own range. By taking advantage of the superior skill of the American gunners at long range, the Americans were able to annihilate the Spanish fleet in a short time, with practically no loss to themselves. But it may be said that the American battleships were infinitely stronger than the Spanish cruisers. This certainly cannot be said in regard to the triangular fight between the two powerful Spanish torpedo-boat destroyers and the little American yacht, "Gloucester." Sidney Low, writing in the *Pall Mall Gazette*, after speaking of the total destruction of the Spanish fleet with practically no loss on the part of the Americans, points out that the determining factor is the man who fires the gun, the man who wings the torpedo on its way, the man who pulls the lever in the engine-room, the man who has the nerve and skill to use the ram. If he is not capable and resolute, all the rest is nothing. Speaking of the Gloucester, he says:

> The Gloucester's fight with the two torpedo-boat destroyers is enough to make one distrust all paper calculations for ever. Theoretically, Lieutenant Wainwright's vessel should have been a sinking wreck five minutes after she had the temerity to challenge the Furor and the Pluton. The American vessel was a lightly-built yacht, hastily turned into a warship by having a few six-pounders and three-pounders mounted on her decks. The two destroyers are supposed to represent the very latest results of modern naval architecture. They were built in English dockyards, and they are fitted with enormously powerful engines, which are supposed to give them a speed of twenty-eight or thirty knots an hour—ten knots at least faster than their victorious antagonist. They carried fourteen-pounders, six-pounders, and Maxims, and,

according to certain of our authorities, two or three of them ought almost to be a match for a battleship. But the yacht simply smothered them with her well-aimed gun fire, and drove them ashore in flames, without receiving a touch herself! It is a most astonishing triumph of mind over matter—of skill and spirit and judgment over men handling immeasurably superior weapons and lacking the capacity to use them effectively.

The American gunners had been highly trained; large sums of money had been expended in ammunition to be used in target-practice at sea. Every man knew his gun, and had confidence in himself while the greater part of the Spanish gunners probably fired the large guns of their fleet on the morning of the action for the first time.

There can be no question that the Spaniard individually has quite as much personal bravery as the American, but he has no taste for machinery, is not an engineer, and is completely without the skill which is necessary in order to understand and handle the ponderous and complicated machine that one calls a battleship or cruiser of to-day. Hand-to-hand sea-fighting is a thing of the past; naval battles are engineering conflicts between machines, and the man who understands these machines best is the man that is sure to win.

Before the battle of Manila the Spanish government seemed confident. They pointed out that they had more ships at Manila than the Americans could possibly bring against them; moreover, the place was well fortified. However, early one morning they found the American fleet in the bay, and it very soon engaged all their ships while lying under the guns of the fortifications. Notwithstanding that the Spaniards in their fortifications and ships had considerably more guns than the Americans, the fight was of short duration, the Spanish fleet being destroyed in a very short time, while not a man was killed on the American side. Here again we find that the Spanish ships and guns were in a wretched condition; everything had been allowed to go to ruin; the gunners seemed quite unable to hit anything. On the American side, on the contrary, everything seemed to be perfect; nothing was out of order; and Admiral Dewey, in writing, speaks of the care that had been taken in training the gunners, and of the gratifying results from the high character of the men employed and the careful training they had received. Here again it was a triumph of technical skill and high training over a complete lack of skill and what one might call criminal negligence on the part of the Spaniards.

The Spanish officers and gentlemen are as intelligent and as refined as those of any country; many of the merchants and bankers conduct their business with great skill and care, and accumulate large fortunes. In no part of the world are there greater integrity and honesty in commercial transactions than in Spain; no merchants stand

higher than the Spanish. In literature they are perhaps superior to ourselves, while in art they have far surpassed us; but they have no taste for engineering, and it is impossible for them to appreciate the necessity of taking good care of machinery.

The Spanish and French newspapers, at the beginning of the war, referred to the United States as a nation of *commerçants* and pig-stickers. Had they referred to them as a nation of engineers and skilled mechanicians, they would have been much nearer the mark. If there is anything in the world which distinguishes the American, it is his taste—may I say his love?—for the mechanical arts. All the young men are extremely fond of machinery; they all wish to make something,—to build a steam engine or a boat, or to make a gun; and it is this which gives the American, and the Anglo-Saxon everywhere, an advantage over the less skilful nations of the world.

The complication of modern implements of destruction gives to the highly scientific and mechanical races a marked advantage over the untrained and unscientific nations. The greater the complication, so long as advantages may be derived from it, the greater the skill required to understand and use the instrument, the greater the supremacy to be derived from its use. I think it may almost be said that naval warfare has reached so high a degree of development and requires such a mass of intricate and complicated machinery as to render it completely useless to unscientific nations. The wisdom of a government in insisting that everything relating to warfare should be constructed in its own country is apparent. If a nation make its instruments of warfare, it will certainly be able to use them.

The war has taught us, too, the small value of torpedoes as compared with heavy artillery. Many naval engineers have contended that the torpedo boat would be much less dangerous in actual warfare than was supposed, and the war seems to sustain their view.

I think the war has also shown that the heavy gun throwing steel projectiles at a very high velocity, so as to have a flat trajectory, is the arm *par excellence*, the arm which we must depend upon in naval warfare, and that thick and heavy armour-plate more than compensate for the additional weight and loss of speed involved. It has also shown the great value of battleships as compared with cruisers,—that is, in a pitched battle; but it has not shown that cruisers are unnecessary. Had the Spanish cruisers been well cared for and well handled, there can be no question that they would have inflicted very serious damage upon the American fleet, and, might perhaps have bombarded some of the coast cities. The war has proved that we should stick to high-power guns and the conventional forms of cruisers and battleships, and keep the navy free from cranks and fads.

EUROPEAN AND AMERICAN BRIDGE CONSTRUCTION.

By Gustav Lindenthal.

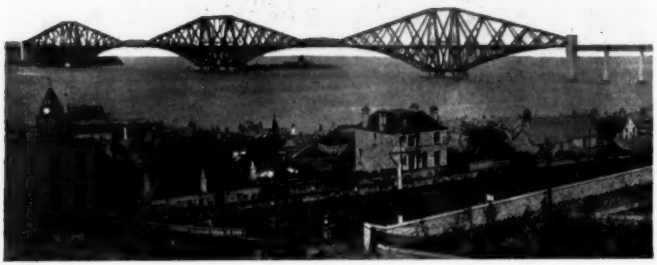
FEW engineering works so fill the beholder with wonder and admiration as a large bridge, a ponderous mass, supporting itself in mid-air, the embodiment of vast resistance and strength.

Visitors to the largest bridge in existence, the great steel cantilever bridge over the Firth of Forth, ten miles above Edinburgh in Scotland, or to the great Brooklyn suspension bridge in New York, rarely fail to have their emotions and love for the grand and colossal aroused. Curiosity is excited as to what past ages have achieved, and as to whether the future will produce still grander works in bridge-building, and the conviction is natural that these monuments of human skill represent, more emphatically and more impressively than any other concrete achievements, the great strides of modern progress.

And it is true that the character of the large bridges in any age, or of any country, furnishes an accurate index of the character of its civilization and of its material wealth. Closely connected with the construction of great highways, and these again happening only when a nation has attained commercial or military prominence, bridge-building tends toward a broader humanization. It was always one of the great and noble arts; as such it was commemorated by the ancient Romans.

To them the erection of the first bridge over the Tiber at Rome, the oldest historical bridge in Europe of which we have any record, the famous "Pons Sublicius," was an achievement so important that its maintenance and the perpetuation of its glory were entrusted to a special order of priests, the "Pontifeces," and membership in this order carried with it high distinction in the councils of State. Its head was the "Pontifex Maximus," traditionally a title of greatest dignity to this day, having descended to the head of the Catholic Church, the order of bridge-builders thus antedating, and surpassing in honor, royalty itself.

This famous bridge, known also in history through its heroic defence by Horatius Cocles against the Etruscans, the subject of one of Macaulay's poems, was already one of great antiquity when that event took place. It was of hewn timber, resting on piles, and probably not more than six hundred feet long,—an inconsiderable structure, according to present ideas of size. It was rebuilt of stone in the seventh



THE FORTH BRIDGE
Steel cantilever; the largest bridge in the world. The two main spans are 1700 feet each. Carries two railway tracks; completed 1890.

century B. C., and in its place is now an iron bridge, the "Ponte Sublicio."

There were older and larger bridges in the oriental countries,—Babylon, Phœnicia, Egypt, and Greece,—but historical accounts give only scanty information of their construction; probably because, like other work done by slave labor, bridge-building was not considered, by these nations, deserving of fuller record and description.

Through all the ages, up to one hundred years ago, construction was governed entirely by empirical rules, transmitted by tradition. The tools were of the crudest kind (bronze tools, probably B. C.); the lifting of the heavy masses of timber and stone was effected along inclined platforms, and, like the pumping-out of the foundations, by human and animal power. But that, even with these meagre means, several master works were created is testified to by the remains of stone bridges, whose equals, in magnificence and grandeur, are not found in modern stone viaducts.

Thus the boldness and architectural beauty of the "Pont du Gard," at Nîmes, France, with its three stories of arches, together 160 feet high, and with openings of 80 feet, has withstood the storms, and has been the admiration, of nearly twenty centuries.

Nineteen hundred years is the age of the "Ponte Maggiore" in Rome, which to this day carries the aqueduct of the Aqua Claudia.

The conception, as well as the masonry and workmanship, of these

classical structures, shows a wonderful skill, rarely found in modern stone architecture, notwithstanding the infinitely greater mechanical and theoretical resources of to-day.

Through all the centuries following the destruction of the Roman empire, there was as little progress in bridge-construction as in the building of roads and highways. Most of the bridges built during the middle ages over the large streams in Europe were very poor structures, either of the pontoon type, or of fixed spans of framed hewn timber. Stone arches were also built, but so small were the building resources of those days that from fifty to ninety years were required for comple-

THE EAST RIVER SUSPENSION BRIDGE, NEW YORK.
The second largest existing span, 1600 feet. The first steel wire suspension bridge; completed 1883.

tion. To that period belong the still-existing bridge over the Danube, at Regensburg (completed 1146); the first bridge over the Elbe, at Dresden (completed 1260); a fine bridge over the Rhone, at Avignon (completed 1188); at Lyons (1265); over the Mosel, at Coblenz (1334); and the famous stone arch bridge over the Moldau river, at Prague, in Bohemia, to build which required a longer time (145 years) than was required for the building of any other bridge in existence. The construction was mostly under the direction of monks, at that age the only preservers of learning and of Roman tradition.

The few large wooden bridges were primitive structures, held together with the fewest iron bolts, and were repeatedly burned down and rebuilt during the frequent wars. That they were popularly ad-

CAST-IRON BRIDGE OVER THE SEVERN AT COALBROOKDALE.
The first iron bridge in the world. Span 100 ft. 6 in.; completed 1777.

mired as masterpieces of the bridge-builder's skill I know from personal recollection of the long structures on piles and trestle piers, over the Danube, at Vienna and Linz. So it was also with the wooden and pontoon bridges over the Rhine. The largest wooden spans were built in Switzerland, where large timber was more plentiful than elsewhere, and some of these curious and very old structures, well preserved, are still in use. No advance was made in theoretical knowledge through all that time. Flat, segmental stone arches were first used at the beginning of the twelfth century, in place of the half circle invariably used by the Romans. It did not signify, however, a better comprehension of the strains in arches, since the Gothic form was also frequently used, theoretically the most unfit for bridges. The great bridges of our time are of a material which the ancient and mediæval nations considered too precious and too costly for anything larger than swords and armor. Bridges of silver and gold occurred to them, but bridges of iron and steel were not thought of in their highest flights of poetic imagination. They are preëminently the creation of our time, representative of the unprecedented power and greatness of the "iron and steel age."

England, rich in the natural resources for the making of iron, and the earliest large producer of it, had naturally the first iron bridge,

the so-often-mentioned bridge over the Severn river, at Coalbrookdale. It is one hundred and twenty years old, well preserved and in full use. It is of cast iron. Of the same material was the first iron bridge on the European continent, at Laasan, in Silesia, which is one hundred and four years old, and likewise in excellent condition.

The largest American cast-iron bridge is the Chestnut Street bridge over the Schuylkill river, in Philadelphia, built thirty-five years ago. Its architecturally-pleasing appearance is in great contrast to some of the utilitarian abominations built over the same river in later years.

Everywhere cast iron was the kind of iron first used for bridge-building, in imitation of the arch principle, in which the material is wholly in compression.

Soon also wrought iron came into use, and, on account of its great resistance to tension, appearing first in the form of the suspension bridge. To England also belongs the credit of having the earliest and largest bridges of this type. The fine chain bridge at Conway, and a larger one over the Menai straits in North Wales (built 1826), are in a high state of preservation.

Although it is probably true that India and China had the first suspension bridges formed of iron chains, they were very imperfect structures, compared with the above-named English examples.

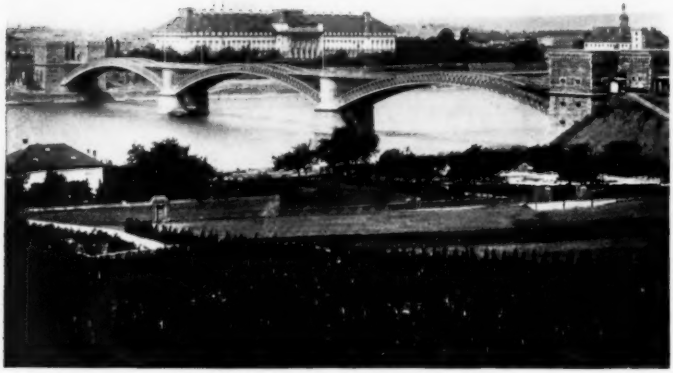
BRIDGE AT LAASAN, SILESIA.
The oldest iron bridge on the European continent; 60 feet span; completed 1794.

CHESTNUT STREET BRIDGE, PHILADELPHIA.
The largest cast-iron arch bridge in the United States. Two spans of 180 feet each over the river Schuylkill; completed 1863.

The evolution of iron-bridge building was very rapid, particularly with the development of theoretical and mathematical knowledge, which was greatly stimulated by the building of railroads. So it came that the largest and most important bridge structures were built for them; and here again we find the fact that countries, like England and the United States, having the densest network of railroads, and also the largest and most important bridges, are in the van of civilization.

To the United States, however, belong the credit and distinction of having produced the first bridge of steel, that precious material which will forever mark our age in history as that of the greatest in human progress. This first monument of the steel age was the St. Louis arch bridge over the Mississippi river, built by James B. Eads and Henry Flad, now both dead. Not only did these masters choose a form of construction architecturally beautiful, and practically and theoretically one of great perfection, but, with rare good judgment, they selected, after the most painstaking investigation, steel of a hard quality as the best material, the strongest and most economical for long spans. In these characteristics, as well as in thoroughness and elegance of details, excellent quality of foundations, masonry, and workmanship, and ingenuity of methods used in its erection, this bridge belongs to the few modern structures which deserve to be termed classical; it is the true "*Pons primus-*

ILLINOIS AND ST. LOUIS BRIDGE OVER THE MISSISSIPPI.
The first steel bridge of the world. Spans 502 and 520 feet. 1868-1874.

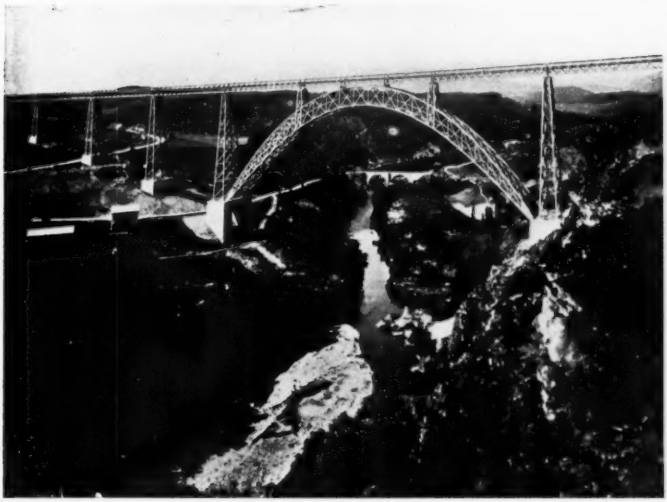


BRIDGE OVER THE RHINE AT COBLENZ.
The first wrought-iron arch bridge; spans 300 feet; completed 1864.

chalybeius" of the world. The design was so far in advance of its own time that it received the endorsement of but few contemporary engineers. It was ten years before the next steel bridge was built; but of all built since none equals it in constructive elegance or in excellence of material.

Many were the criticisms of the design at the time. Only a few could see that it was above comparison with the iron structures proposed in its place, and vehement were the predictions of its utter failure. So far from their coming true, it can be justly said that discriminating knowledge, or want of it, of the theory and practice which guided the construction of that noble structure will always furnish a reliable test of the ability and competency of the bridge engineer.

Endlessly varied are the forms of structures erected in the last twenty-five years, since steel was first used. There are now hundreds of large bridges over wide and deep rivers which otherwise would never have been bridged,—trusses, arches, suspension bridges, cantilevers, and drawbridges, possible with no other material. The great Brooklyn bridge (1,600 feet span), the longest in America, has been surpassed by the great Forth bridge in Scotland, with its two large openings of 1,700 feet each, carrying two lines of track, over which trains race without diminution of speed, and without causing the



THE GARABIT VIADUCT.

The highest iron arch bridge in the world, 380 ft. high, 542 ft. span, over the Truyère, in the south of France.

slightest tremor. This bridge will again be surpassed by the structure over the North river of nearly twice the span (3,100 feet) and eight times the capacity. But that still larger spans are possible is

BRIDGE OVER THE DOURO, PORTUGAL.

Two roadways, one on top, and one suspended below, arch span 566 feet; completed 1885.

the conclusion reached, by a commission of army engineers appointed by the United States secretary of war in 1894. Their report gives, for certain conditions, as the practicable limit of span, 4,335 feet. I have no hesitation in saying that, a bridge with a span of 6,000 feet could be built, for the heaviest trains at express speed.

Fantastic as it may seem, it is nevertheless true that, based on the theoretical resources of to-day, a steel bridge could be built over the Atlantic ocean, which would be perfectly safe, resting on anchored piers which the fiercest hurricane, or the heaviest steamer in collision,

BRIDGE OVER THE ADDA AT PADERNO.
The largest iron bridge in Italy; span 490 feet; completed 1889.

could not disturb, and with long spans so high above the water that the tallest vessels could safely pass under them. Financially such a bridge is impossible, because its cost would be greater than the combined free wealth of all the nations; and, practically, it would be absurd, because of no commensurate benefit to mankind. It illustrates, however, the vast progress in knowledge which eliminated from the modern bridge engineer's vocabulary the word "impossible," except in the sense that engineering possibilities are limited by financial possibilities, and by them only.

A mere description of all the great steel bridges already built would fill many volumes. But most interesting it is to notice the evolution of the type, nearest in kind to that of the stone arch, in which the carrying capacity is derived from the compressive strength

BRIDGE OVER THE SCHWARZWASSER CREEK, SWITZERLAND.
Largest arch bridge in Switzerland; span 380 feet. Completed 1882.

of the material. That the greater strength of iron and steel results in a light and graceful appearance is strikingly shown in the views herein presented. An arch bridge is always more pleasing than a truss or beam construction, which is, however, a most suitable form where mere utility is the leading consideration.

However grand the achievements in iron and steel bridge building may be in the future, one important fact will distinguish and limit their age from all others. In all probability, the steel age will be the shortest in history. It will end at a time, perhaps, no farther removed from the present than the present is from the time of the Crusades. In Europe and America, at least, steel bridges will be then creations of the past. This will be so, because, for the production of steel and iron in large masses, fuel in large quantities is necessary. Charcoal was the exclusive fuel and reducing agent, before mineral coal was used. Once the mineral fuels (coal, petroleum, natural gas, or their products) are exhausted, the production of iron must revert to the limitations of the charcoal period.

Authorities estimate that the coal-fields of Europe and America will last from four hundred to fifteen hundred years longer. Those of Asia and Africa are not yet fully known. Measured by the age of the Egyptian pyramids, the steel age will, therefore, be of short duration, but the most glorious in the history of mankind.

The expectation that progress in the sciences will discover new

ways of making iron and steel in large masses without fuel, or with very little fuel, cannot be fulfilled. Power for mechanical purposes mankind will be able to obtain from the four other great sources of nature (wind, tides, waterfalls, and the heat of the sun), but mineral fuel is the only great source of power which can also be used for the reduction of iron ores. Once gone, it cannot be replaced or reproduced. Moreover, the development and most extensive use of the four other sources of power cannot be achieved without metals, and, foremost, without iron and steel for the necessary appliances, machinery, and structures. Without coal, no iron and steel; without iron and steel in great masses, no great machinery for utilizing the sources of power. In view of this fact, already known as well as we can ever know it, the question how long steel and iron bridges will last becomes most important, because the time must come when they cannot be replaced. Will they last as long as stone bridges, of which, as mentioned before, we have some two thousand years old yet in use?

The answer can be given now with as much certainty as one thousand years hence.

A strong and well-designed iron or steel bridge, effectually protected against corrosion, will endure many centuries,—in fact, should endure forever.

But the qualifying conditions are important ones. By a strong

IRON ARCH BRIDGE OVER THE BALTIC CANAL AT LEVENSAN.
Carries a railroad and a wagon way; span 520 feet; completed 1894.

IRON ARCH BRIDGE OVER THE BALTIC CANAL AT GRUENENWALD.
Span 510 feet; completed 1894.

and well designed structure is meant one in which every part is secure as shown by calculation against over-straining of the metal, within now-well known limits, from any loads or forces that may legitimately affect the structure.

The alleged crystallization and final brittleness of iron and steel, through long-continued use and vibration, is a fable, unworthy of scientific belief, because unsupported by germane facts. It originated from the frequent fracture of over-strained and abused metal, in which the proper limits of allowable stress were not observed. Iron so over-burdened will break down, vibration or no vibration, just as an over-burdened horse will break down. The familiar legend of the fiddler, who could if persevering enough, fiddle down a bridge, which is meant to be metaphorical of the destructive force of cumulative rhythmical oscillations, need cause no apprehension that a strong and properly designed metal bridge can ever suffer or break down under the regular step of a regiment marching to music. A metal bridge can be made just as safe in that respect as a stone bridge. With stresses in iron and steel not exceeding one-third to one-tenth of the breaking strength, the durability will surpass that of stone arch bridges, in which the pressures usually range from one-tenth to one-twentieth of the breaking strength of the stone, provided that the one other condition, protection against corrosion, be observed. This,

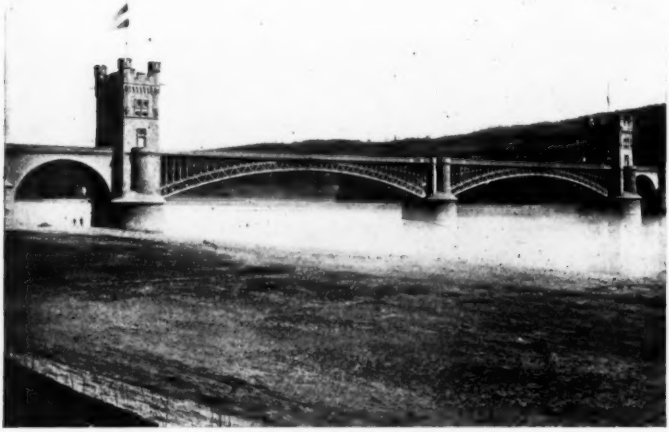
it must be admitted, has been so far found a difficult, if not impossible, condition.

Good stone requires no such protection. Well-built stone masonry will slowly deteriorate through ages, as the rock of mountains deteriorates, through the action of changing heat and frost, rain and wind.

But, while iron and steel resist temperature influences better than stone, they suffer more from the chemical action of water and air, and particularly from acidulous gases and moisture, for the exclusion of which from the iron surfaces no known paint gives prolonged protection.

That is to say, the durability of iron and steel structures will depend first upon the permanent scientific skill with which they are inspected and protected. Since the painting and constant care against corrosion constitute a permanent expense not required by stone arch bridges, the latter, notwithstanding their larger first cost, should always be favored in places where an economic advantage accrues from the saving in cost of maintenance.

What are the position and prospect of the United States regarding the commercial field of bridge construction for other countries, is a question often asked. A few months ago J. Stephen Jeans, secretary



BRIDGE OVER THE RHINE AT DUISBURG-HOCHFELD.
Spans each 550 feet; completed 1896.

THE WASHINGTON BRIDGE OVER THE HARLEM RIVER, NEW YORK. 1886–1889. SPANS 510 FEET.

STEEL ARCH BRIDGE OVER THE NIAGARA RIVER.
Carries railroad and roadway, taking the place of the famous Niagara suspension bridge. Span 550 feet. Completed 1897.

to the British Iron and Steel Institute, gave, in a series of articles published in this magazine, facts and reasons for the supremacy of the United States in the manufacture of iron and steel. Briefly stated, they are based on the great abundance of cheap and excellent fuel and iron ore, and low freight rates by rail and water, in the United States.

The far-reaching consequences from these facts have become apparent only within the last few years. Along with the great reduction in the price of steel rails as the principal steel product there has been a corresponding decline in prices for structural and bridge work.

The best and strongest bridges built anywhere in the world are to be found on the best American railroads. It is on them that first grew up the practice of thorough, systematic inspection, minute specification, and an exactness of workmanship equal to that in locomotive work.

The American bridge-builders are better equipped than those of other countries to compete for the many large metallic bridges that will be needed in countries not having their own bridge-works, like Japan, China, South and Central America, Africa, Asia Minor, the East Indies, Australia, and the West Indian and Asiatic Archipelagoes. The answer, therefore, to the before-stated question is that, if systematic efforts, through well-organized agencies, are made for obtaining this trade, it will surely go in open competition to the United States, by reason of their superior manufacturing facilities, which permit construction at a low cost. It is an indisputable fact that no other country builds its metal bridges as cheaply, albeit of excellent workmanship, as the United States. The difference in price for completed work is frequently as great as forty per cent., in favor of American work.

But, in this connection, I wish to say that more attention will have to be given to the æsthetical side of construction. It cannot be denied that, in that regard, America is behind the standards of Europe. There the more important bridges, particularly in cities, are invariably designed with a view to their architectural appearance. Details of construction are subordinated to it. The American practice is regulated more from the standpoint of utility, of quick fabrication and speedy erection, not always with the happiest results architecturally. Although the United States has the largest number of steel and iron bridges, it has also the distinction of having the ugliest. There are certain indications, however, of an improvement in taste, and it is entirely within the possibilities of the near future that American engineers will be able, in foreign competitions, to furnish designs for bridges at once architecturally meritorious and economic of cost.

THE COMPARATIVE COST OF STEAM AND WATER POWER.

By William O. Webber.

RECENT investigations into the changes in costs of steam and water power for the last twenty-five years develop results so surprising that they cannot be comprehended by the general public sufficiently to enable them to intelligently weigh the economic results that tend to influence the general industrial situation at the present day. There has been a great deal of talk and a great deal of writing, in the last few years, regarding the diversion of trade from one country to another and from one section to another, the whole force of this discussion seeming to be concentrated on one idea,—that such changes and diversions are due, in the first place, to the wages paid and the class and skill of the workmen employed, and, in the second place, to improvements in the machinery used,—entirely ignoring what seems to the writer one of the most important items in the case, —namely, the cost of power,—both the first cost, and that of the transmission of this power into useful work.

Taking, for instance, the steam engine as a prime mover, and taking the figures from a number of able articles on this question by such writers as F. W. Dean, we find that twenty-seven years ago—say, in 1870—the most economical engines in use in the United States were the Corliss simple condensing engines, which were using from nineteen to twenty pounds of steam per h.-p. hour. This was a vast improvement over 1860, when the steam-consumption was nearly double that amount.

At the same time English mill engines had been largely improved; but the advent of the Corliss engine, both in America and Europe, was followed by a marked improvement in the economy of steam-consumption, and twenty pounds per h. p. was considered good work.

The English engineers were the first to introduce the compound engine in mill practice, but their example was soon followed in this country, and resulted in reducing the consumption of steam to sixteen pounds per h. p. per hour. This was followed by still further improvements, lowering the consumption to fourteen pounds. The thirteen-pound mark was soon reached by increasing the steam pressure and increasing the ratio of expansion between the high- and low-pressure cylinders. The English engineers then modified this mark

by the introduction of triple-expansion engines, following that by quadruple-expansion engines. While but few of these have been introduced as mill engines in America, a great many have been used as pumping engines, with a marked increase in steam economy. Recently there has been introduced a simple, cross-compound, condensing engine, with a ratio of volume between the high- and low-pressure cylinders of 4½ to 1. This engine, with 160 pounds' initial pressure, has developed a h. p. on 11½ pounds of steam per hour. To realize what this means in dollars and cents, we must go back a little. We find that, assuming our engines of 1870 to have been using 20 pounds of steam with a boiler evaporating 8 pounds of water per pound of coal used, the total cost of this plant, including engines, boilers, buildings, chimney, and all accessories, was about..... $70.00

per i. h. p. Taking the figures of charges on such a plant as:

Interest	@6%
Depreciation	@4%
Repairs	@2%
Insurance	@1%

13% of the total cost of $70.00..... $9.10

and taking coal at 2½ pounds per i. h. p. per hour at $7.10 per ton, we have $\frac{2\frac{1}{2} \times 10 \times 308 \times \$7.10}{2240} =$..... $24.40

Attendance on boilers, three day men at $1.50 per day, and one night man at $1.50, that is, $\frac{\$6.00 \times 308 \text{ das.}}{1000} =$ ... $1.85

Attendance on engine, one engineer at $3.00 per day, one assistant at $2.00 per day, that is, $\frac{\$5.00 \times 308 \text{ das.}}{1000} =$ ... $1.54

Oil, waste, and supplies..... .... $1.25

Making a total cost of..... $38.14

per h. p. per hour on a 1,000-h. p. plant. But, to fully show the difference due to changes in the plant alone, we must use the figures just quoted on the basis of the present cost of coal per ton. Therefore, substituting the price of $3.85 per ton for $7.10, we reduce to $26.99 the cost per annum, in 1870, of a steam h. p. for large units of 1,000 h. p.

Taking this as a fair statement of the cost of steam power using a plant of the best character available twenty-five years ago, but using coal at present prices, we are prepared to institute a comparison with what can be done at the present time with steam power.

According to Mr. Dean's paper, a similar plant can be installed to-day for..... $57.00
per i. h. p., with a compound engine using 12½ pounds of steam and boilers evaporating 9 pounds of water and 1.4 pounds of coal per i. h. p. for total coal consumed.

Taking fixed charges.....	@ 5%
Average depreciation.....	@ 3½%
Repairs...	@ 2%
Insurance and taxes.....	@ 1%
Total.....	11½%,

and we have 11½% of the total cost of $57.00..... $6.55
With coal-consumption of 1.4 pounds per i. h. p. per hour at
$3.85 per ton, we have $\frac{1.4 \times 10 \times 308 \times 3.85}{2244} =$..... 7.41
Attendance on boilers, two day men at $1.50 per day, and
one night man at $1.50 per day, that is, $\frac{\$4.50 \times 308}{1000} =$ 1.39
Attendance on engine, one engineer at $3.50 per day, and
one assistant at $2.00 per day, that is, $\frac{\$5.50 \times 308}{1000} =$.. 1.69
Oil, waste, and supplies..... ..... .80

Making a total cost of..... $17.84,

showing, in twenty-seven years, a saving in first cost of 18.6 per cent. and a saving in operation of 53 per cent. The actual returns from the two best plants known to the writer has further reduced these figures to $12.00 per h. p. per year. What this means in actual economy may be shown as follows:

At the rate of $27 per h. p. per annum, taking a mill or other manufacturing plant with a capital stock of $1,000,000, and requiring about 2,000 h. p., this cost of power would represent 5.4 per cent. of the capital stock. The actual figures from a yarn mill in Massachusetts in 1889 gave the cost per i. h. p. per year as $20.67, representing 4.13 per cent. of the capital stock. Taking our 1897 figures of $17.84, the cost would represent 3.56 per cent. of the capital stock. Taking our last figures of $12, the cost would represent 2.4 per cent. of the capital stock, or a saving of 3 per cent. on the capital stock over the plant of 1870.

This last figure does not seem so astounding when it is considered that the simple superheating of steam can reduce the steam-consumption from 12.5 pounds to 10 pounds per h. p. per hour; that a num-

ber of engines have been built in the last year or two, consuming only one pound of coal per i. h. p. per hour; that the introduction of mechanical stokers and other coal-handling machines has largely decreased the attendance on boilers; and that there has been a saving of 5 per cent. due to vertical engines, of 7 per cent. due to vertical internally-fired boilers, and of 2 per cent. due to improved grates.

The lowest actual figure known to the writer to-day is $11.64 per h. p. per annum, the coal costing $1.76 per ton. The plant consists of a vertical, cross-compound, condensing engine, built by the E. P. Allis Company, with high-pressure cylinder 32 inches in diameter and low-pressure cylinder 68 inches in diameter, both of 5-foot stroke and making 75 revolutions per minute. The cylinders have a ratio of volume of 1 to 4.5, and the working pressure is 150 pounds. The condenser is operated by an independent air-pump, driven by a small vertical Corliss engine. The load now carried averages 1,950 h. p., and, to give this, the required mean effective pressure of the high-pressure cylinder is about 55 pounds, and of the low-pressure cylinder about 12 pounds. The steam pressure is 155 pounds. The boilers are of the Heine water-tube pattern, having 216 square feet of grate surface and about 7,500 square feet of heating surface. An exhaust steam heater in the exhaust pipe of the low-pressure cylinder warms the water to about 120 degrees; it is then pumped through a Green Economizer, which carries the temperature to a point varying from 215 degrees to 250 degrees. Draft is produced by a chimney 175 feet in height.

The coal used is semi-bituminous, of a grade somewhat inferior to Cumberland or Pocahontas, and costs $2.26 per gross ton, delivered in the yard, close to the boilers.

The following is a tabulated statement of the cost of power:

Fuel per h. p. per year of 3,070 hours	$4.70
Labor	1.88
Supplies and repairs	.42
Total operating expenses	$7.00
Interest at 5 per cent	$2.05
Depreciation at 5 per cent	2.05
Taxes	.41
Insurance	.04
Fixed charges	$4.55
Total cost of power per year	$11.55

The fuel includes the fuel used in banking fires at night, and that required for the supply of five slashers.

If the steam used for other purposes than power were deducted, I believe it would reduce the fuel by 10 per cent., or 47 cents per h. p. per year, making the total $11.08. The tons of fuel used per h. p. year is 2.08.

At $11.08 per h. p. per annum the cost per power is 2.2 per cent. of the capital stock, and shows a saving of 3.2 per cent. over the plant of 1870.

This is certainly a very fair dividend to be obtained as a saving in cost of power alone, and one which should not be ignored in these times of close competition.

Besides this, there are the losses in transmission, which can be reduced greatly, and the increased production due to constant speeds, fully maintained, which can be effected by electrical means, resulting in another saving fully as large. These are facts, not fancies; they can be demonstrated by actual figures in the possession of the writer.

Another feature of this power problem is the extremely low cost per h. p. per year for water-power plants developed in late years and not encumbered by an octopus in the form of a land and water power company, which puts such a burden on the users of water power that they cannot compete with more favorable localities.

In a paper written by the writer's father, Col. Samuel Webber, in 1895, for the American Society of Mechanical Engineers, the cost of installation is placed at $100 per h. p.; probably it has exceeded this very largely, owing to the changes involved in new wheels, etc.

At Augusta, Ga., the cost of construction was $90.00 per h. p.; at Columbia, S. C., the cost was only $72.00 per h. p. The cost of the Concord Water Power Company on the Merrimack river was $63.72 for minimum of 3,300 h. p., and a cost of $42.05 for average of 5,000 h. p. These are costs of dams and canals. To this should be added costs of pits and foundations and wheels, bringing up the cost for average flow, for whole plant, to $57.75, and for minimum flow to $78.88, per h. p.

Now, basing the calculations of cost on the minimum flow, allowing

5%	for interest,
2½%	for sinking funds,
1½%	for repairs, and
1%	for taxes, we have
10%	total annual cost,

equal to $7.89 per h. p.; and, adding 75c. per h. p. for oil and attendants, a total cost of $8.64 per h. p.

The total cost at Columbia, S. C., is $9.50 per h. p., and at Augusta, Ga., $11.05 per h. p.

I have recently figured the actual cost of developing a small water power, and obtained the following results:

Dam complete	$ 266.84	
Filling	60.00	
Carpenter work	150.00	
		$476.84
Wing walls 270′ × 9′ × 3′ @ $3.25 cu. yd	810.00	
Digging and filling	162.00	
		$972.00
Forebay, including rack, gates, etc.		680.00
Race way 8′ × 16′ × 320′ = 1517 yds. @ $1.50 cu. yd		2275.50
Tail race 8 × 16′ × 150′ = 800 " " 1.50 "		1200.00
Tail race walls = 150 " " 4.00 "		600.00
Wheel pit = 231 " " 6.00 "		1386.00
Wheel pit excavating = 85 " " 1.50 "		128.00
Masonry, flash boards, and rack		380.00
Flume and forebay, 7′4″ × 10′4″ × 200′. Lumber 25000′ @ $11.00	275.00	
2″ plank 8 × 8 timbers 4′ apart. Bolts 3c. lb.	75.00	
Labor on same	200.00	
		550.00
Second flume 20′ long		60.00
Second tail-face 200′ × 8 × 10 = 600 yds.		900.00
		$9608.34
2 35″ wheels in horizontal case	$2200.00	
2 draft tubes and flume and iron work	400.00	
		$2600.00
1 27″ wheel	950.00	
Flume, draft tubes, and iron work	200.00	
		1150.00
		$13358.34
Cost of plant per horse-power, $42.15.		
Cost of plant, total, $13,358.34 @ 6%		$800.00
Depreciation on $3750 @ 5% (wheels and iron work)		187.50
Depreciation on $1086 @ 10% (wood work)		108.60
Repairs per annum		100.00
Insurance, $4836 @ 1%		48.36
Taxes @ 2% on $13,358.34		267.00
Attendance, oil, etc., per annum		200.00
Cost per annum, improvements alone		$1711.46
Value of riparian rights, $500.00		
Interest @ 6%		$30.00
Taxes		10.00
Cost per annum, including land adjacent to pond		$1751.46

The maximum total power of the three wheels is 510 h.p. and the mimimum, 161 h.p., and the average is 315 h.p., the latter giving for the cost of the power $5.42 per h,p. per annum, or including the land flowed and adjacent to the pond, $5.56 per h.p. per annum.

THE UNDERGROUND RAILWAYS OF LONDON.

By Frederick E. Cooper.

WHEN, in course of time, the construction of railways connecting London with the principal towns of Great Britain could be no longer delayed, many considerations, principally public prejudice, necessitated their termination on the outskirts of the metropolis. Thus, on the north side of the Thames the termini of the London & Bristol (now the Great Western Railway), the London & Birmingham (afterwards merged into the London & North-Western Railway), and the London & Colchester (now the Great Eastern Railway) were originally located at Paddington, Chalk Farm, and Shoreditch respectively, each distant about three miles from Charing Cross. Similarly on the south side the London & Brighton Railway had a terminus jointly with the South Eastern Railway, the line to Dover, at London Bridge, and the London & Southampton Railway stopped short at Nine Elms, each being about two miles distant from the before-mentioned central point.

In these days of time-saving and fully-recognised importance of public convenience it is amusing to recall the arguments then put forward against the advance of railway facilities towards the business centres and residential districts of the metropolis. Royal commissioners gravely reported that they thought the advantages to the public of bringing railway stations further into the city had been exaggerated, because they found, on enquiry, that the average distance travelled by passengers who arrived at Euston was sixty-four miles, and concluded that the saving of a mile or two was of little importance.

It was not long, however, in the case of the London & Birmingham Railway, before it became sufficiently obvious that the out-of-the-way situation of their proposed London terminus would be a great inconvenience to their passengers and a great hindrance to their business. Therefore the extension of that line was taken in hand, and completed to Euston square in 1838. Some years afterwards the London & Southampton Railway was extended to Waterloo, but a longer interval elapsed before the extensions of other lines to Victoria, Charing Cross, and Liverpool street were carried out. The Great Western Railway has, in its intimate connection with the Metropolitan Railway, a practical extension of its system and a means

METROPOLITAN RAILWAY EXCAVATION; NOTTING HILL. 1869.

of distributing its traffic in the city and central portions of London.

The extension of the London & Birmingham Railway from Chalk Farm to Euston square, though short, is of special interest in connection with the subject of the present paper; for it was the first example of underground-railway construction, and in the details and difficulties encountered much useful experience was gained, by which subsequent undertakings profited.

From the commencement, at the crossing over Regent's canal, to Euston square, the length is 1⅛ miles, of which 1,526 yards consist of bridges and covered ways and open cutting with retaining walls, the remainder being occupied by the station. The bridge over Regent's canal is of the bow-string type, 50 feet span, and has been much admired. It is of cast iron, with tension members formed of wrought-iron bars (two to each girder and 3½ inches in diameter), the utility of which was, at the time, gravely doubted by some engineering authorities. The covered ways and bridges, having an aggregate length of 310 yards, are double, each 25 feet wide with a 4-foot pier between; in some instances the covering is a brick arch 2 feet 5 inches thick, elliptical in form, with a rise of 8 feet; but, where the rails are nearer the surfaces, crescent-shaped cast-iron girders are made use of, 2 feet deep at the centre

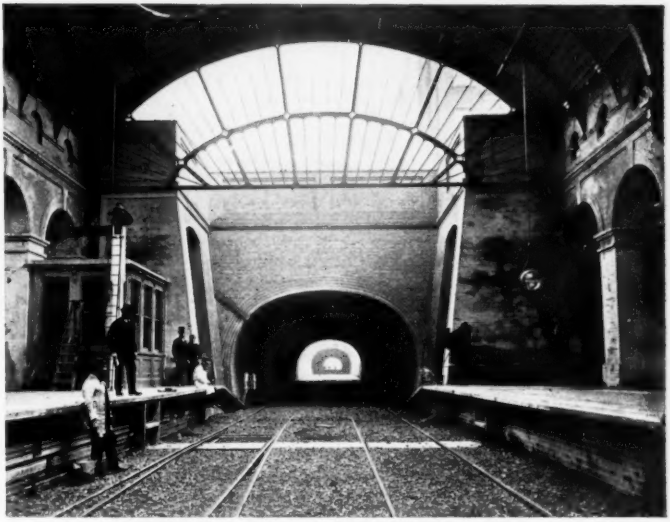
METROPOLITAN RAILWAY; WORKS AT PRAED STREET.

and 1 foot deep at the ends, with a rise of 2.6 feet and spaced 6 feet apart, jack arches 9 inches thick being turned between them. The retaining walls had a curved batter on the face, but, being somewhat light in section, the treacherous material behind them has for years given much trouble, for, though cast-iron struts 54 feet long were interposed between them, and their thickness was much increased, they have not proved stable, even when wrought-iron struts were substituted for those of cast iron.

The level of the rails at Euston station is no less than 54 feet below that at the canal; consequently the gradients are rather severe, a considerable portion being 1 in 64. When first constructed, owing principally to the opposition of the owner of the land traversed, the use of locomotives was prohibited on this extension, and the trains were hauled up the incline by rope-traction, the engines being situated near the canal bridge, while those for Euston were run down by gravity alone. In course of time, because of the noise of the pulleys on which the rope ran, and the smoke nuisance (more or less imaginary) of the locomotive, locomotives were made use of to haul the trains, in place of the rope. Two were generally attached to each train. That in front was detached on reaching the canal, and, running quickly ahead, was turned into a siding, while the train pursued

its course with undiminished speed. But for many years the incoming trains descended the incline under the control of hand-brakes alone, after the necessary impulse to start them had been given by a locomotive in the rear.

About the middle of the century public attention was most intensely directed to railway construction, chiefly on account of its probably lucrative character as an investment, but also, in the minds of far-seeing men, on account of its immense possibilities for public convenience. Naturally the metropolis became the field for numerous schemes designed to provide it with adequate railway facilities. With-



METROPOLITAN RAILWAY NEAR PRAED STREET.

out referring to many of these, which, of great interest in themselves, have since, in a modified form, been carried out, I shall describe here only that which may be deservedly considered the most complete example of urban railway construction,—namely, the Metropolitan, or, as it is popularly termed, the "Underground" Railway.

The origin and early development of this work were as follows. The New road, now divided into Marylebone, Euston, and Pentonville roads, the most northerly of the great east and west routes in London, being a fine broad thoroughfare, with the main buildings, as a rule, lying well back on each side, has been, from early days, the scene of attempts to improve locomotive facilities. Along this road,

METROPOLITAN RAILWAY, NOTTING HILL RETAINING WALLS.

sixty years ago, the steam carriages of Hancock and others, the prototypes of the auto-car, plied successfully, and it was only when physical obstacles to their progress were made use of, in compliance with ignorant prejudice, that they were withdrawn.

It is not surprising, therefore, that this road should be suggested as the course for a railway, which could be constructed beneath its surface with but little expense for property,—that most important item in the cost of urban railways. Parliamentary powers were sought and obtained, in 1853, for the construction of such a railway, extending from Paddington to Kings Cross. Having now obtained a footing, the promoters proceeded to develop and improve the scheme, and modifications were introduced, the principal feature being a connection with the Great Western Railway, then terminating at Bishop's Road, Paddington, and its practical extension to the very centre of the metropolis, where a convenient piece of land, going to the north of Holborn and west of Farringdon street, had lately, through the action of the city authorities, been cleared of its wretched dwellings and more miserable inhabitants, so well described by Dickens in "Oliver Twist." An act for the extensions, east and west of the authorised line, for the objects above described, was obtained in 1854, and, shortly after, branches to the Great Northern Railway, then

recently opened, were added to the scheme. After many difficulties, financial and other, the works of the modified line were commenced in 1860, and the line from Bishop's Road to Farringdon street was opened January 10, 1863.

The length of the line is 3¾ miles, 3 miles of which are beneath streets for the occupation of which no payment was made. About ¼ mile was constructed on cleared ground, the property of the City of London, for which a comparatively nominal sum was paid. The remainder is under land acquired under compulsory powers, and at that time covered generally by a poor class of dwellings. The types of construction adopted were brick-arched covered way, open cutting with retaining walls with and without struts between, and ordinary driven tunnel. The arch covered way, forming about sixty-five per cent. of the whole length, was made use of when the rails could be laid at about 20 feet below street level. The arch was elliptical in form, and 2 feet 5 inches thick at the crown. The radius of the centre part is 19 feet, and that of the haunches 9 feet 3 inches. The side walls at the foundation are 4 feet thick, and at the springing 2 feet 5 inches, where they are 28 feet 6 inches apart, that width being sufficient to permit of the passage of the Great Western Railway Stock, at that time built to a gauge of 7 feet ½ inch. The

METROPOLITAN AND DISTRICT RAILWAYS, DOUBLE COVERED WAY, SOUTH KENSINGTON.

excavation, as a rule, was made to the full width of the structure, 33 feet 6 inches, the sides being kept in place by closely-placed poling boards supported by horizontal walings about 3 feet apart, strutted to the opposite, at intervals of about 7 feet, by whole timbers. The cost per yard was about £50. About half of the material excavated was clay, the remainder being gravel and sand.

Generally, during the progress of the work on the site of the roadway, the roadway was closed in sections about 200 yards in length, the traffic being diverted to the side streets, often for periods

METROPOLITAN AND DISTRICT RAILWAYS; DOUBLE COVERED WAY, KENSINGTON.

of as much as four months. This diversion and dislocation of the traffic was found to be an intolerable nuisance; consequently, in after times, under similar circumstances, the public authorities insisted on temporary roadways for at least a portion of the width of that affected. The cost of this was considerable, amounting sometimes to 5 shillings per square foot.

In its course the line traversed high ground at Clerkenwell, necessitating the driving of a tunnel 728 yards long, which was completed in eighteen months at an average cost of £70 per lineal yard.

Two of the stations at each end were constructed within retaining walls, with open iron and glass roofs; but those at Baker street,

DISTRICT RAILWAY; COVERED-WAY GIRDERS, WESTMINSTER.

Portland road, and Gower street, being beneath the roadway, are brick-arched structures 45 feet wide. Air is admitted at the sides through openings lined with white glazed tiles. The platforms were 300 feet long and 12 feet wide, but were increased to 15 feet on the abolition of the broad gauge. The cost of such a station was about £18,000 in excess of that of the covered way for the same length.

In order to provide facility of access to the stations from the streets, and to diminish the cost of excavation, the railway was constructed at a level as near as possible to the surface. Consequently there was considerable interference with gas and water pipes and sewers. Where it was possible and convenient, the latter were diverted; but in two instances, where the courses of the lateral valleys—that of the Tybourne and that of the Fleet—were crossed, costly structures had to be executed to carry them over the railway. The Fleet was crossed no less than three times, the conduits being cast-iron tubes of maximum dimensions of 10 feet in width and 10 feet in height, supported on cast-iron girders.

The traffic of this first length of line opened was a surprise to every one; for two months after that date the number of passengers was at the rate of nearly three millions per mile per annum as compared with 7,361 on the Great Western Railway, the receipts per mile per annum being more than £600.

DISTRICT RAILWAY OPPOSITE SOMERSET HOUSE, 1869.

The year 1863 was marked by the extraordinary amount of attention devoted to the relief of the continually-increasing traffic in the streets of London.

A committee of the house of lords was appointed to consider the question, and they came to the conclusion that there were many and great objections to the concentration of the railway traffic by the construction of central joint stations, but that it "would be desirable to complete an inner circuit of railway that should abut upon, if it did not actually join, nearly all the principal railway termini in the metropolis, commencing with the extensions in an easterly and southerly direction of the Metropolitan Railway from Finsbury circus at the one end, and in a westerly and southerly direction from Paddington at the other, and connecting the extremities of those lines by a line on the north side of the Thames."

As an outcome of this recommendation the Metropolitan Railway Company applied in the ensuing session for powers to extend their existing line at each end, westward through Notting Hill to South Kensington and eastward by way of Aldgate to the Tower. Incorporation of an independent body was proposed for the purpose of completing the southern portion of the circuit, by way of the Thames Embankment, by the construction of the Metropolitan District Rail-

way. These proposals, after some modifications, and with the support of the local authorities, were sanctioned, the total length of the circle being a little more than 13 miles, and the number of stations being 27.

Among the many suggestions of the before-mentioned committee was one which appealed strongly to those using the public thoroughfares, being that, except where unavoidable, railways should not be carried along beneath existing streets where it was proposed to interfere with the surface, but that private property should be acquired for their construction. This was no doubt a very wise suggestion, as it put a stop to the very objectionable temporary closing of the streets and dislocation of the traffic using them; and, as the railways were thus diverted to private property, opportunities were afforded by which the ventilation of the line and stations, already found defective in the original line, could be much improved by breaking up the lengths of covered way by open cuttings. On the other hand, it was possible to recoup some of the cost of the land by erecting upon the covered ways, when not beneath streets or public property, buildings of a suitable character. To such an extent has this been done that there is now hardly a single spot on either line which, where the conditions permit, is not covered by buildings of some sort.

DISTRICT RAILWAY; CHATHAM PLACE.

The Inner Circle Railway was not completely joined up until late in 1884, the last portion constructed being that between Mansion House and Tower Hill, a distance of three quarters of a mile. The enormous value of the land traversed, and the costly works necessary to adequately maintain the traffic along, and to secure against injury the houses on each side of, Cannon street, beneath which the line is constructed for a length of about 300 yards, had for many years deterred the companies interested from venturing on the outlay, and it was

DISTRICT RAILWAY; THAMES EMBANKMENT, 1869.

chiefly owing to the contribution of £800,000 by the authorities, on condition that certain new streets be made, that it was undertaken.

After 1863 construction along the remainder of the circle proceeded in a manner similar to that adopted for the original portion of the Metropolitan Railway; but, as there was no necessity of providing for broad-gauge stock, the width of the covered ways and the distance between the retaining walls in the open cuttings was reduced to 25 feet. For many reasons also it was frequently desirable to reduce the distance between rail-level and the surface of the streets above. In such cases cast-iron girders, generally 2 feet 6 inches deep, spaced 8 feet apart, with 14-inch jack arches between, formed the roof. The side walls were panelled and 5 feet 6 inches thick. The cost was in-

CONSTRUCTING WIDENING LINES UNDER EXISTING METROPOLITAN RAILWAY.
Farringdon Street, looking south.

creased about £12 per cubic yard. The stations, as a rule, were placed in open cuttings within retaining walls covered in with elliptical arched iron and glass roofs 50 feet 6 inches span. They have short lengths of open cutting at the ends, for ventilation. The platforms are 300 feet long and 15 feet wide, the extra cost varying from £14,000 to £22,000.

Since 1874 the permanent way, much modified at various times, has been of bull-headed steel rails, weighing 87 pounds per yard, in chairs of 47 and 39 pounds' weight, on sleepers 12 inches by 6 inches laid 2 feet 8 inches apart.

Much variation in the cost of the works per mile of the different portions of the Inner Circle is not to be wondered at, when the circumstances attending their construction are considered. The original Metropolitan Railway cost about £186,000 per mile, while the last-completed portion, from Mansion House to Aldgate, cost at least double that amount.

The capacity of the Inner Circle Railway is limited by the shortest interval between trains,—about 2½ minutes,—and the maximum number of passengers in each train,—nominally 420, though on occasions those standing increase it 50 per cent. Under extreme cir-

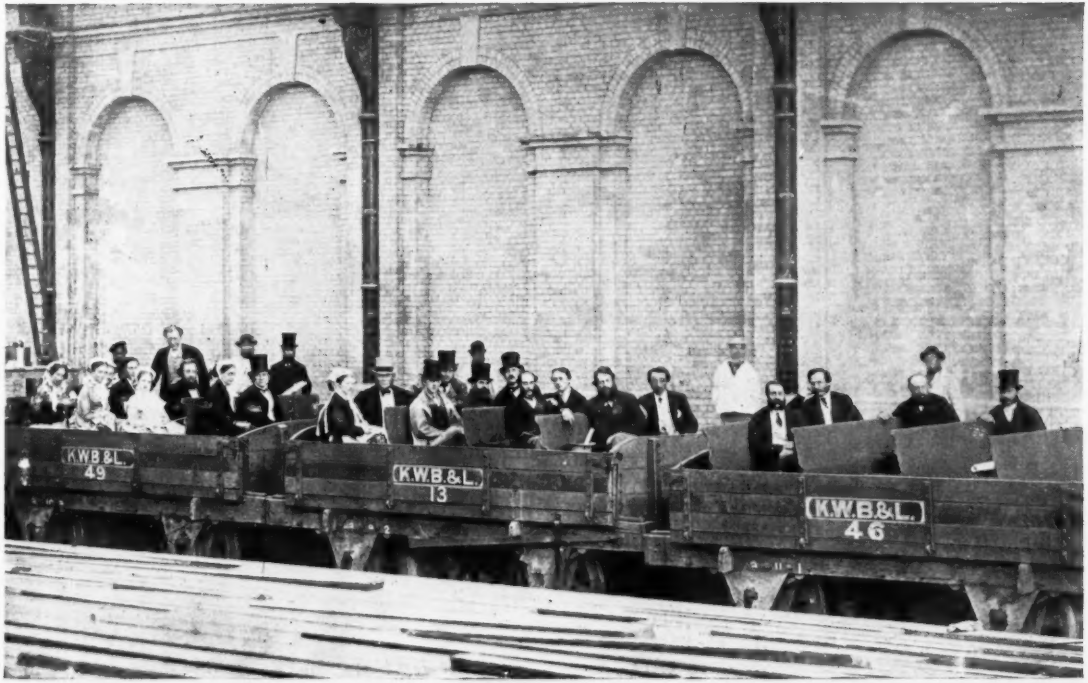
WIDENING LINES COMPLETED UNDER EXISTING METROPOLITAN RAILWAY.
Looking south.

cumstances as many as 15,000 could be conveyed in each direction past a given point in an hour.

A complete circuit of the line is made in 70 minutes. Deducting a stop of 30 seconds at each of the 27 stations, the average speed is about 14 miles an hour.

As so large a portion of the original line was to be completely cov-

CONSTRUCTING WIDENING LINES UNDER EXISTING METROPOLITAN RAILWAY.
Looking north.



a b c d e f g h i j k l m

METROPOLITAN AND DISTRICT RAILWAYS; PRIVATE INSPECTION, 1868.

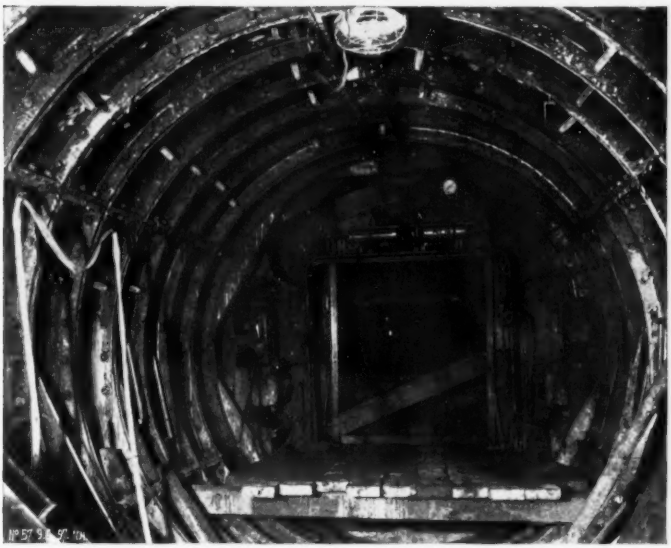
a. Mrs. Gladstone; b. Countess Percy; c. Alderman Gilpin; d. Viscountess de Vesci; e. Mr. Gladstone; f. Sir John Fowler, Chief Engineer; g. Lord Ronald Gower; h. Sir William Harcourt; i. Mr. Woolner, Sculptor; j. Hon. P. Stanhope; k. Duke of Sutherland; l. Mr. J. A. Walker, Contractor; m. F. E. Cooper, Resident Engineer.

WIDENING LINES COMPLETED UNDER EXISTING METROPOLITAN RAILWAY.
Looking north.

ered in, no special provision being made for ventilation, there were certain essentials to be secured in designing the locomotive to be employed, the principal of these being the abolition of visible steam by condensation (no exhaust into the tunnels being permitted) and obviation of the necessity of burning fuel while traversing the line. To obtain the first of these conditions was not very difficult; the attempt to secure the second, by substitution of white-hot firebricks for fuel as a source of heat in the firebox, was abandoned without a trial. A locomotive, however, was constructed, at a cost £4,518, which had a small fire box for fuel and a large mass of firebrick stowed away in the barrel of the boiler, the idea being to work it as an ordinary locomotive with full blast on the open portions of the line, burning an excess of fuel to heat up the firebricks, and, on reaching the covered way, to closely seal the fires with dampers, preventing the escape of fumes. The heat stored up in the firebricks was to keep up the steam. But this locomotive was a failure. After several trials, the locomotives at present in use were designed. These weigh about 43 tons, with 30 tons on 4 wheels available for traction. The fuel first used was a special kind of coke, almost free from sulphur, but expensive. Notwithstanding all precautions, complaints were constantly being made of the impurity of the atmosphere in the tunnels.

Afterwards Welsh smokeless coal was substituted for the coke, on the score of economy. Owing to this, together with the increasing traffic, the nuisance has now reached such a point as to become almost insupportable, and both the Metropolitan and the District Companies are seriously contemplating the use of electricity as the motive power.

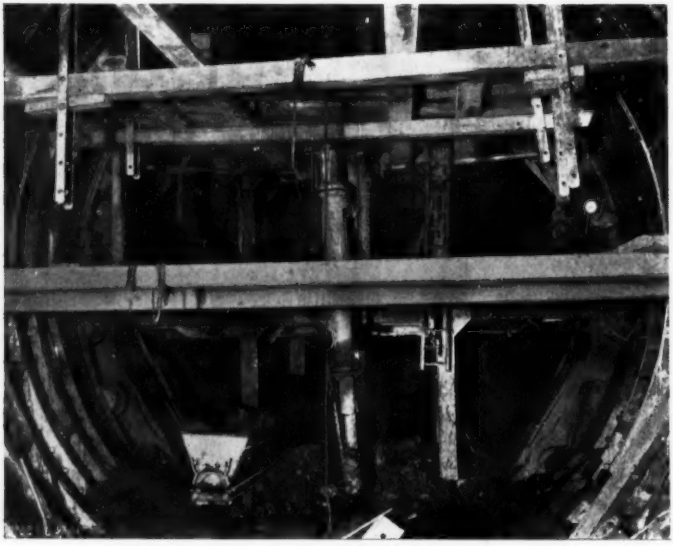
As may be gathered from the foregoing account of the first form in which underground railways were constructed in London, the difficulties to be surmounted in their development were found to be so great that for some years no proposals were entertained. Thorough-



CENTRAL LONDON RAILWAY; 11 FT. 6 IN. TUNNEL AND SHIELD.

fares could no longer be made use of, even if the traffic using them could be maintained uninterruptedly. If constructed through private property, the enormous cost of its acquisition made it almost impossible to hope for an adequate return to the investor. In the case of an authorised line between Euston and Charing Cross, although a substantial guarantee was given by the companies interested, the public would not come forward with the cash. Furthermore, on account of the use of steam locomotives and the consequent difficulties of ventilation, the roads became very unpopular.

In the meantime the ever-increasing traffic in the streets of the metropolis, brought about both by the rapid extension in all direc-



CENTRAL LONDON RAILWAY; 21 FOOT TUNNEL AND SHIELD.

tions of the residential districts, as well as by the great improvement in the facilities for travel afforded by the omnibus companies, the passengers by which have increased about four fold in the last thirty years, called urgently for fresh means of relief from congestion.

This has been attempted with encouraging success by the construction of deep-level tubular railways, constructed, as a rule, beneath main thoroughfares without interference with their surface or with the houses at the sides. These being worked by electricity, the difficulties attending efficient ventilation have been easily disposed of.

The pioneer in this system of construction and working was the City and South London Railway, which, authorised in 1884, was completed and opened at the end of 1890.

This railway is 3 miles 1 furlong in length. Commencing at King William street, near the Monument, it passes under Arthur street West and Swan lane to the river Thames, beneath which it is carried at a maximum depth of 73 feet below high water, the minimum distance between the bed of the river and the top of the tunnel being 20 feet. The railway then, for a distance of 60 yards, traverses Hibernia Wharf and Chambers,—the only private property interfered with,—and thence its course is beneath public thoroughfares *via* High street Borough, Newington Butts, and Causeway, to Stockwell.

For its construction the subway system, as it is called, was adopted, the practicability of which was proved by the formation of the Tower Subway 8 feet in diameter and 1,350 feet long, beneath the Thames, in 1869.

The essential features of this system may be briefly summarised as follows. The work is executed as a driven tunnel,—that is, without interference with the surface, and at such a depth as to be clear of all pipes, sewers, and other existing underground structures, a separate tunnel being formed for each line of way. The tunnels are circular in cross-section and small in size,—of dimensions just sufficient to permit the safe passage of the rolling stock. They are 10 feet 6 inches and 10 feet 2 inches in internal diameter. They are lined with cast-iron plates of such size and weight as to be conveniently handled, and the work is executed within a cylindrical shield, formed of thin steel plates, which sustains the soil while the plates forming the tunnel are put together, one ring at a time, within it. On the completion of this operation, as the excavation in front progresses, the shield is thrust forward by means of hydraulic jacks, uncovering the last ring of plates, and providing, in advance of that, room for the next ring to be put together.

As the forward movement of the shield leaves a cavity round the ring somewhat exceeding the thickness of the shield,—say, about 2 inches,—this might become, if unfilled, a cause of settlement in the soil above, resulting in deformation of the tunnel and damage to buildings in the vicinity. A simple and effectual apparatus has been devised by which liquid lime, by means of air pressure of 60 pounds, is forced into such cavities, completely filling them.

This system, in comparison with the covered ways on the earlier railways, shows the following essential differences. First, iron plates are substituted for brick linings, saving an appreciable quantity of excavation; secondly, instead of supporting the soil during the construction of the work by a costly system of timbering, the putting in of which is a tedious operation, and much of which is buried and lost, a movable shield is adopted, available for the whole of the section carried out by its aid; thirdly, the work can be executed in short lengths, generally 20 inches, which, together with the filling-in of cavities as described, prevents all movement of the soil, either by settlement, or exposure to the air for a long period. On the original lines, in many instances, movements of the soil did more or less damage to buildings in the neighbourhood.

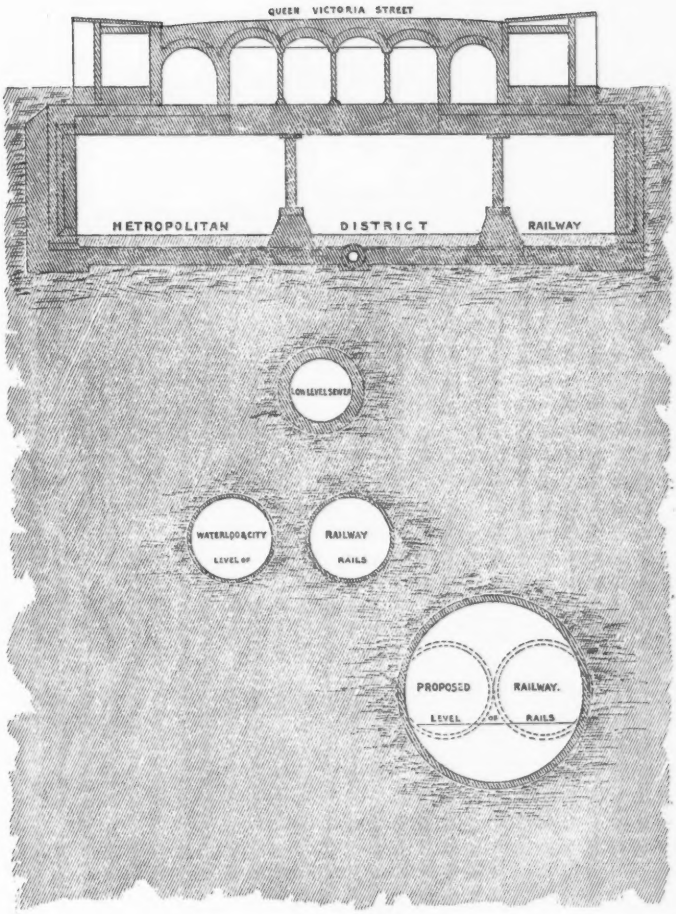
Beneath London the greater portion of the subsoil is London clay, and, though near the river, it is often overlaid with gravel, generally not of great thickness—rarely exceeding 20 feet. This clay is ex-

ceedingly suitable for the execution of tunnels on this system; it is perfectly dry and homogeneous (except when nodules of septaria are met with), and, if exposed only a short time, it is very stable; on the other hand, it is exceedingly hard and tough, and thus difficult to get. So great are the advantages for working which this material affords that, wherever possible, the tunnels constructed on this system have been kept sufficiently low down to be wholly within it; consequently the distance between the platforms and the surface of the streets is often considerable, varying on this line between 67 feet, at King William street, and 43 feet, at Stockwell. On a portion of the Clapham road a depression in the clay, filled with gravel charged with water under a head of 35 feet, necessitated the construction of about 200 yards of the tunnel under compressed air. About 50 yards near the city terminus was similarly dealt with,—of course, at greatly-increased cost. The enlargements at the stations, six in number, were constructed in brickwork, the excavations being timbered in the manner usual in ordinary tunnels. At the intermediate stations they are 200 feet long, 20 feet wide, and 16 feet high, each line having its separate tunnel with a platform 10 feet wide. At the terminal stations they are 26 feet wide and 20 feet high, and of greater length. Passages constructed in brickwork conduct the traffic to the staircases and lifts. The latter are of great utility, and, when introduced, were a novel substitute for the stairs. Notwithstanding the many objections urged against the use of lifts, their constant use on this line, and their almost universal adoption in lofty buildings all over the world, prove these objections to be ridiculous. Certainly without them deep-tunnel railways would fail to attract or deal with the amount of traffic necessary to ensure success.

The lift cages work in shafts 25 feet in diameter, lined partly with iron plates and partly with brickwork. They are nearly semi-circular in plan, and there are two in each shaft. They conveniently accommodate fifty to sixty passengers, who enter and leave at each end without confusion.

In the act authorizing the construction of the City South London Railway the use of steam locomotives was prohibited, the original intention being to use an endless-cable system of rope haulage; but so satisfactory had been the progress made with electrical traction during the time occupied by the construction of the line that that motive power was adopted, with very successful results.

The trains generally consist of three carriages of the tram-car pattern, carrying 100 passengers, and are of a total weight of 40 tons. The locomotives, weighing 10½ tons, have two axles, with a motor on each, driving direct without gearing. The electric current at 500



SECTION OF QUEEN VICTORIA STREET.
Showing existing and proposed structures.

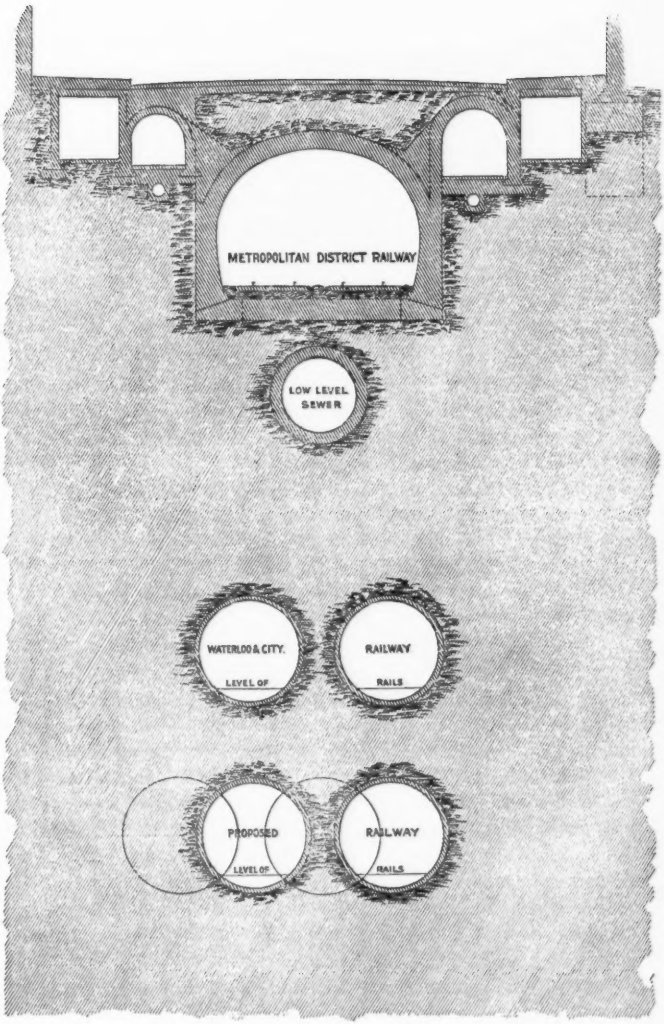
volts is delivered to the conductor, which is a steel channel weighing 10½ pounds per yard. There are three collectors on each locomotive. The return circuit is through the rails. The average speed, including stops, is 11½ miles per hour, and between stations 13½ miles, with a maximum of 25 miles per hour, when 100 h. p. is developed, the electrical efficiency of the locomotive being 70 per cent.

During the construction of the City South London Railway, and shortly before its completion, powers were sought for the construction of a line, appropriately named Central London Railway, on the deep-level subway system, to be electrically worked, traversing the metropolis from west to east. Commencing in the Bayswater road at Queens road, it was to be carried along, but far beneath that road and *via* Oxford street, Holborn, and Cheapside, to a station near the Bank. As this line of traffic is probably the most densely crowded and congested in the world, it was rightly considered a most suitable course for a railway of this description. After a hard fight before committee, the bill was rejected. This result was due, no doubt, in some measure, to the fact that the method of working proposed had not, at that time, been proved a success; in fact, the Metropolitan Railway Company, one of the chief opponents, adduced evidence to prove that electric traction had been tried, at a cost of £20,000, on the Manhattan Railway of New York, and found a complete failure, the loss of power being no less than 85 per cent., leaving the efficiency but 15 per cent.!

In the following year, 1891, the scheme, so modified as to place the western terminus at Shepherds Bush, was again brought before parliament, this time with a successful result, partly owing, no doubt, to the satisfactory working of the City South London Railway, which had been open for some months, and which completely disposed of the allegations of the principal opponent at the preceding session.

The Central London Railway, including the extension to Liverpool street, authorised in 1892, is a little more than 6 miles in length, and there are fourteen stations, the greatest and least distance between stations being 58 and 31 chains respectively.

Some time elapsed before the financial arrangements were satisfactorily concluded, and not until 1896 did construction begin, since which time it has made satisfactory progress. The method of construction is similar to that described in the case of the City South London Railway tunnels, but the Central London tunnels are of larger dimensions, being 11 feet 6 inches in internal diameter. The station enlargements are also circular, 21 feet in diameter, sufficient for a platform 32 feet long and 11 feet wide, and lined with iron plates. West of Marble Arch there is but one lift shaft, 30 feet in



SECTION OF QUEEN VICTORIA STREET.
Showing existing and proposed structures.

diameter at each station. At each intermediate station on the remainder of the line there are two lift shafts, 23 feet in diameter, and at the Bank there are five, of a diameter of 20 feet. As a rule, there is at each station one stairway shaft, 18 feet in diameter, containing separate staircases for the ascending and descending passengers.

Westward of Farringdon street the railway tunnels and station enlargements are practically complete, and on the remainder of the line good progress has been made.

With the exception of a short length on the branch rising up to surface at the generating station at Shepherds Bush, the line is constructed below the surface of the London clay; in fact, there is in one case a statutory obligation to have a minimum of 20 feet cover. Near Tottenham Court road the lower portion of the tunnel for some distance is laid in the Reading beds,—a formation underlying the London clay.

The distances between the rail level and the surface of the road are least at Shepherds Bush and Westbourne Stations, where they are 54 feet 3 inches and 55 feet respectively, the maximum, 100 feet, being at Notting Hill Station.

As the cost of the work varies so much, according to the price of materials and labor, local conditions, and other disturbing elements, it cannot be detailed with sufficient accuracy to serve any useful purpose; but a general idea may be formed from the following statement of the labor and materials per lineal yard required in the 11-foot-6-inch and 21-foot tunnels and in the 23-foot shafts: cast iron, 2 tons 17¼ cwts., 8 tons 5¼ cwts., and 6 tons 13 cwts.; bolts, 2 cwts., 6¼ cwts., and 2½ cwts.; excavation, 14 cubic yards, 45 cubic yards, and 50 cubic yards, respectively. To accommodate the traffic expected, which must be very great to ensure adequate returns for the heavy expenditure, adequate provision is being made.

The trains, 105 tons in weight, will consist each of seven carriages, accommodating 336 passengers. The electric locomotives will be very powerful, weighing 48 tons, upon 4 axles with a motor on each. Allowing for a stop of 20 seconds at each station, the speed will average 14 miles an hour, and the whole distance will be traversed in 25 minutes,—a great saving in time as compared with the existing omnibus journey of 1¼ hours. As a maximum, twenty-four trains per hour will be run in each direction.

Power will be generated at Shepherds Bush, and the current, at 5,000 volts, will be distributed at various points along the line, where it will be transformed down to 500 volts before being conducted to the locomotives.

The Waterloo City Railway, now rapidly approaching completion,

is practically an extension of the London & South Western Railway from Waterloo to the Bank, the length being about 1½ miles, of which 1,000 feet are beneath the Thames.

Its construction is similar to that of the Central London Railway, but the tunnels are 12 feet in diameter, and access to the surface at each terminus is afforded by inclined footways in place of lifts.

Along Queen Victoria street the tunnels have been driven not only beneath the existing structure of the Metropolitan District Railway, but also beneath the low-level sewer, a brick tunnel 8 feet 6 inches in diameter, the minimum distances from rail-level to rail-level of the former and to the invert of the latter being about 48 feet and 20 feet respectively.

Among the many examples of this type of construction which have been authorised by parliament the boldest and most unique is probably the proposed doubling of the Metropolitan District Railway by constructing beneath it a tubular railway from Earls Court to the Mansion House, a distance of 5 miles.

The tunnels are to be 12 feet 6 inches in diameter, and the rails are to be laid at depths varying from 18 feet 6 inches to 75 feet below the rails on the present line.

In traversing Queen Victoria street the top of the tunnels will, for a distance of 1,000 feet, be 8 feet beneath the lower portions of the tunnels constructed here by the Waterloo & City Railway.

There will be only two stations on this line, to be constructed beneath the existing Victoria and Mansion House Station, and access to the present platforms will be afforded by lifts and staircases.

The total number of journeys made during 1897 on the system of the Metropolitan Railway was 95,000,000, and on that of the District Railway 45,000,000, of which 43,000,000 and 22,000,000, respectively, pertain to the urban or underground portions of these systems. On the City & South London Railway the journeys in 1897 were about 7,000,000, making a grand total for the year, on the underground systems of London, of approximately 72,000,000.

SOME COMPARATIVE POINTS OF INTERNATIONAL PATENT LAW.

By J. Sinclair Fairfax.

THE oldest law of patents in the world is the British, James I, by the celebrated Statute of Monopolies of 1623-4, having abolished all monopolies then affecting the industrial welfare of the people, except patents for inventions.* These were limited to a period of fourteen years, and were granted for the purpose of establishing new manufactures within the realm, whereas pre-existing monopolies controlled the sale or manufacture of some of the most important articles of common use, such as coal, oil, salt, vinegar, glass, tin, lead, and iron. The grant for the monopoly of an invention was by open writs or letters, called "Letters Patent," so named to distinguish them from the closed letters of the sovereign, which are sealed on the outside; but other "Letters Patent" than those for inventions, such as are given for distinctions and appointments, continue to be granted by the crown to the present day.

The antiquity and form of British patent law naturally influenced other countries when drawing up similar laws, such changes as were made arising from the form of government, local requirements, and general experience gained in the working of the older law.† In the United Kingdom the original term of fourteen years still remains, and this is the case in India and most of the British colonies. In Canada it is now eighteen years, although formerly it was fifteen. In Belgium, Spain, Mexico, and Chili it is twenty years as a maximum, with some discrimination against patents of importation. Until the act of 1861 the United States term was fourteen years, with a privilege of extension; but subsequently it became seventeen years without such privilege. If the British patentee of a meritorious invention can satisfy the Judicial Committee of the Privy Council that he has not been adequately rewarded, despite his exertions, her Majesty in council may grant a further term of fourteen years, or any less term that its merits may suggest; but such extensions are seldom granted, and rarely exceed seven years. The majority of European countries

*For an excellent commentary on the Statute of Monopolies, and a *fac-simile* reproduction of the King's Book of Bounty (1610), on which it was founded, see "Monopolies by Patents," by J. W. Gordon, London. Stevens & Sons, Ld., 1897.

†The first law of patents in France was established in 1791, by the Assemblée Nationale, under the First Republic.

grant fifteen years as the maximum term, with conditions for the payment of annual taxes and working of the invention in the country within a limited period.

Separate patents were formerly required for England, Scotland, and Ireland, but now the British patent covers the three countries, and extends to the Isle of Man. From time to time changes have been made in the law, the most important of late years being the acts of 1852 and 1883. By the former the applicant for a patent had the option of proceeding with a provisional specification, which did not require drawings, claims, or a minute description of the invention, the latter being explained in general terms only. If the applicant proceeded, he was required to file a complete specification within six months from the date of his provisional, giving a detailed description of the means for carrying out the invention, and receiving in due course the Letters Patent bearing the great seal. This option of proceeding with a provisional specification is continued under the present law of 1883, with, however, an extension of the term from six to nine months, the patent subsequently obtained dating from the date of application.*

Many American inventors, and a few English ones, apply for the British patent with a complete specification, which, in the former case, is usually a copy of the United States specification as passed for issue, after an examination for novelty. This is a good plan, but the application, in most cases, should be filed in England not later than the date of issue of the United States patent, to avoid any question of prior publication, which would invalidate the patent. One objection, however, to applying with a provisional is that no action can be brought for infringement until the complete specification has been filed and accepted, it being obvious that the public are ignorant of the monopoly desired by the inventor until after he has formulated and published his claims. Nevertheless, the practice of applying with a provisional is popular in Great Britain, as the date of filing the application (if not affected by the international convention) fixes the date of a patent subsequently granted thereon, thus safeguarding the inventor's rights while he is making experiments or applying for foreign patents before he discloses the exact details of the improvements. Otherwise an inventor might unintentionally publish his invention (thus invalidating the subsequent patent) during the experimental stage, either directly by his own act in publicly showing the invention, or by disclosure on the part of a workman employed to

* "Patents, Designs, and Trade Marks Act, 1883." This is the principal act, but it has been amended in certain particulars by acts bearing the same title, passed in 1885, 1886, and 1888.

put it into a commercial form; but this danger does not occur in filing a complete application in the first instance, with claims and drawings, in which case, presumably, the invention has been fully thought out and presented in its finished condition. Owing to the two years provision of the United States law,* the danger of disclosing an invention, previous to applying for a patent in England, is not sufficiently appreciated by American inventors, many of them making their application some time after the issue of their patent from Washington.

Another danger is incurred by American inventors in not appreciating the different meanings applied to the term "first inventor" on opposite sides of the Atlantic. With one exception, it means in the United States the actual person who first reduced the idea constituting an invention to a practical form.† Some other person may have independently arrived at the same result, and even obtained a patent for the identical invention, yet the original inventor may obtain a patent subsequently which will override the prior one.§ In other words, the actual inventor is not required to be the first applicant at the Washington patent office, whereas the first applicant at the London patent office is deemed the first inventor unless the case comes under the International Convention for the Protection of Industrial Property, or fraud is shown. Furthermore, in England, the "first inventor" may not have taken any part in making the invention, as an applicant who first introduces a foreign invention is deemed in law to be the true and "first inventor." The exception above referred to in United States practice is that, if an invention has been made in a foreign country, but not patented anywhere, or described in a book, the American inventor may subsequently obtain a valid patent for the same invention.**

The form of the British application is consistent with monarchical government and the origin of patent law, being by petition.†† The

---

* "Rules of Practice in the United States Patent Office," December, 1897. Rule 24, "Revised Statutes" of the United States, section 4,886.

† "No doctrine is better settled than that the subsequent inventor who perfects his invention and adapts it to use while one prior to conceive is unreasonably delaying is, in contemplation of law, the original and first inventor, and is entitled to a patent for the invention." Lay v. Wiard, *United States Official Gazette*, IX, p. 349.

§ "The right of a prior applicant will not be prejudiced by reason of a patent being issued inadvertently to a subsequent applicant, and the burden of proof rests upon the latter in trial for interference." Gordon v. Withington, *Off. Gaz.* IX, p. 1009.

** "Rules of Practice," 27; Rev. Stat., sec. 4,923.

†† "And whereas the said inventor hath humbly prayed that we would be graciously pleased to grant unto him (hereinafter together with his executors, administrators, and assigns, or any of them, referred to as the said patentee) our Royal Letters Patent for the sole use and advantage of his said invention." Form of Patent, Pat. Des. and Trade Marks Act, 1883.

applicant supplicates the crown for a monopoly according to the provisions of statute law, and, if a patent is granted, it is under conditions which have come down from James I, and are still claimed as crown prerogatives. But, influenced apparently by the British example, without its reason or consistency, the United States application is also in the form of a petition, addressed to the commissioner of patents.* The power to establish a patent law came from the people in this instance, and was delegated to the general government by the several States when they formed the Union; therefore the executive officer should simply be requested (and not petitioned, as for an act of grace) to examine the alleged invention according to law, and to issue a patent thereon if no anticipation be found. Nor is the petition required with the application the only one, inasmuch as a petition is also addressed to the commissioner of patents under Rule 145, when the examiner's decision on certain points is questioned. It seems more logical to put these matters of procedure upon the basis of a legal right, rather than apparently on the commissioner's favour.

The title is of much more importance in the British Islands than in the United States, the officials in the latter country altering it within certain limits to suit their forms of indexes and classification of subject-matter. The Mother Country, however, insists that the title shall correctly indicate the subject-matter of the invention, and, even if a title is accepted by the patent office, a British court of law may declare a patent invalid by reason of a defective title, as the public might otherwise be purposely misled by an incorrect or ambiguous title. It requires, therefore, careful consideration, after the nature of the invention has been fully described and understood. The title should be sufficiently comprehensive to embrace the full scope of the invention without going beyond it, and yet not too circumscribed, as some patents have been declared invalid for having titles too wide, and others for having titles too narrow. The title should be explicit, but should not disclose the invention, as such disclosure would amount, after the making of the application, to publication of the invention, and enable others to profit by the disclosure in completing prior applications, or in obtaining patents in other countries. The whole object of the title is to give a sufficient indication of the invention to any one interested in its subject, and therefore it must not mislead the public.

The subject-matter for which a patent may be granted is defined and limited in Great Britain by the sixth section of the statute of monopolies, which reads as follows:

* "Rules of Practice," 33; Rev. Stat., sec. 8,488.

Provided alsoe that any declaracion before mencioned shall not extend to any letters patents and graunts of privilege for the tearme of fowerteen yeares or under, hereafter to be made of the sole working or makinge of any manner of new manufactures within this Realme, to the true and first inventor and inventors of such manufactures, which others at the tyme of makinge such letters patents and graunts shall not use, soe as alsoe they be not contrary to the lawe nor mischevous to the State, by raisinge prices of commodities at home, or hurt of trade or generallie inconvenient; the said fourteene yeares to be from the date of the first letters patents or grant of such priviledge hereafter to be made, but that the same shall be of such force as they should be if this Act had never byn made, and of none other.*

This has been interpreted by the British courts to embrace a process; but a wider field of subject-matter is permitted in the United States than is possible under the foregoing section. In the latter country, and apart from patents for designs, a patent may be obtained by any person who has invented or discovered any new and useful art, machine, or composition of matter, or any new or useful improvement thereof, not known or used by others in the United States, and not patented or described in any printed publication before his invention or discovery thereof, and not in public use or on sale therein for more than two years prior to his application.†

The widest construction is allowed in American practice under these provisions, many patents being issued for the slightest step in the art to which they relate, the improvement being so small as to require the most refined discrimination for its discovery. Such patents frequently form one of a series of almost similar microscopical inventions that would certainly be covered by a single patent in England, or by one or more patents of addition in France, Belgium, or Italy. They arise in adapting a known invention to conditions slightly different from those ordinarily met with, or by slight changes in form, function, or arrangement of the elements employed, to save cost, time, or some slight labour of the operators. To these refinements, and the endeavour of rivals to evade or improve upon them, much of the advance of American industry is due, and the aggregate effect is to intensify European admiration of American ingenuity.

In several of the continental countries patents are not granted for certain classes of subject-matter, however ingenious they may be. In Russia, for example, medicines, and many articles used in warfare, may not be patented; the same is the case in Switzerland with regard to chemical inventions, processes, or improvements which cannot be presented as physical objects. In Germany articles of food, medicines, and chemical products are refused, and in France medicines or similar compositions. We trace in some of these restrictions the influence of

*"Monopolies by Patents," by J. W. Gordon, London, 1897.

†"Rules of Practice," 24; Rev. Stat., sec. 4,886

the above-quoted section of the statute of monopolies, "soe as alsoe they be not contrary to the lawe nor mischevous to the State, by raisinge prices of commodities at home, or hurt of trade or generallie inconvenient."

The question of novelty is all important to every patentee, as, when this question is raised in the court, the monopoly sought must either stand or fall thereby. We know that a preliminary search for novelty is made by a government department of the United States, but, even if satisfactory, the patent granted thereon is liable to be declared invalid by the judicial branch of the same government; and this practice obtains in other countries where the like search is made. While it is apparently inconsistent for a government to take away with one hand the monopoly conferred by the other, it is probably in the interest of inventors and the public that an independent and impartial tribunal, used to the taking and sifting of evidence, should consider the question of validity in the light of specific charges, especially as considerations other than novelty may enter into the decision. Nevertheless it is believed by many inventors that a government issuing a patent should guarantee its validity, especially where the preliminary search for novelty has been made; and this view meets with some slight response in Russia and Germany, where an infringer is liable, under certain circumstances, to imprisonment, as if he were deemed guilty of a minor act of high treason in violating a grant conferred by the sovereign.

There are many practical reasons against guarantee by industrial nations of the patents they issue, however satisfactory it might be to disappointed inventors. To do so would probably revive some of the grievances sustained under the rule of Queen Elizabeth, or such as obtain at the present time under concessions given by oriental despots to their favourites. It is better to throw the onus entirely upon the patentee in express terms, as is done in Great Britain, where he is warned in the patent "provided that these our Letters Patent are on this condition, that, if at any time during the said term it be made to appear to us, our heirs or successors, or any six or more of our Privy Council, that this our grant is contrary to law, or prejudicial or inconvenient to our subjects in general, or that the said invention is not a new invention as to the public use and exercise thereof within our United Kingdom of Great Britain and Ireland, and Isle of Man, or that the said patentee is not the first and true inventor thereof within this realm as aforesaid, these our letters patent shall forthwith determine, and be void to all intents and purposes, notwithstanding anything hereinbefore contained." In France the patentee is obliged to mark the patented article with an inscription in full, or the initial

letters thereof, S. G. D. G., indicating that it is without the guarantee of the government, thus warning the public that all concerned must themselves investigate the validity of the grant, or the usefulness of the article.

Wherever an examination for novelty precedes the grant of a patent, the official examiner necessarily has the power of rejection; and, as important inventions have frequently been deemed at the outset to possess little, if any, patentability, this power of rejection is considered by many as the greatest defect of the system. To enable the examiner to make the required search, it is essential that all prior subject-matter be carefully analysed and sub-divided into suitable classes for reference; and, unless this is done accurately, and kept up to date, the system becomes illusive, and even dangerous to those depending upon its supposed advantages, as invalid patents would be issued after a supposed complete search had been made. In Germany eighty-nine classes of subject-matter have been established to facilitate searches; in the United States two hundred and twenty-five classes existed at the beginning of 1897, and these were again minutely sub-divided, Class 39—fences—alone having ninety-nine sub-classes, while changes are constantly being made. The British arrangement comprises one hundred and forty-six classes, but, no official search being made, the classification enables an interested person to search for himself, and this is further facilitated of late by the publication of a series of abstracts of specifications relating to the several classes. A brief description with an illustration, but without the claims, is generally given for each patent; and volumes at a cheap rate, referring to different periods from 1617, are now being issued, and will be brought up to date as soon as it can be done by the limited staff available.

The report of a United States examiner almost always necessitates re-drawing of the claims to avoid the prior references he cites; and, as functional claims are rarely permitted, the claims usually take the form of combinations of the operative elements employed in performing a particular action or function required in co-operating to the general result. These claims are often most ingeniously worded, and drawn with the most minute discrimination, yet so as to carry the widest possible interpretation. The claims thus become very numerous, in order to cover the whole of an invention, but modfications of importance must be separately covered by other patents. In England functional claims and several modifications frequently appear in one specification, but with few claims, and those of a much wider scope than the American ones. The British claims, however, are automatically restricted in number, for (in cases of infringement), if one

claim only is bad, it vitiates the patent, even though that particular claim was not infringed, and not otherwise brought into the action. The German claims are still broader than the British, and more liberally interpreted in the courts, being required to refer to the general nature of the invention, and not to particular subordinate combinations, while the French practice lies somewhat between the British and the German.

It may be useful to point out, in conclusion, that, while but one copy of the specification and of each sheet of drawings is required at the Washington office, two copies of each are required in England, France, Belgium, Germany, and many other countries, the reason for the differences varying. In the United States the examiner himself is empowered to make the alterations required on the filed specification, and the office may be employed to correct the drawings. In England the examiners are prohibited from doing this, the originals being returned to the applicant or his agent for the purpose, and the duplicate set kept as a check upon unauthorized amendments, and for public reference while the original is at the printers. In Germany the duplicate is kept for similar reasons; but in Belgium and several other countries, where they do not print the specifications and drawings (or, as in France, only those which survive after a certain time), the duplicate set is stamped and returned with the Letters Patent to the applicant for his keeping. In Italy three copies of the drawings and specifications are required, in order that one set may be filed at Turin, the former capital of the kingdom of Sardinia, and the second set at Rome, the capital of united Italy. India requires five copies of the drawings and specifications, one being filed in each of the presidencies or provinces, and one in Burmah.

BACTERIAL PROCESSES OF SEWAGE PURIFICATION.

By Rudolph Hering.

IN a previous article the conditions were discussed under which sewage can be finally disposed of, without offence, by dilution in large bodies of running water. In the present article conditions are to be assumed under which such dilution is impracticable or improper, so that the sewage must be purified before it is discharged into a water-course.

Here again we are met at once with the fact that, if we seek a single method adapted to all conditions, no solution of the problem is possible. There are several methods that will give satisfactory results, and the immediate surrounding circumstances must govern the selection of the one to be applied. To do this, we have again certain guiding lines which are well fixed, and which will be discussed below.

Sewage is water polluted by organic matter partly suspended and partly dissolved therein. It contains also bacteria in great quantities, some of which are disease-producing, but most of which are engaged in the work of transforming lifeless organic into inorganic matter. Nitrogenous matter, being less stable than carbonaceous matter, is more rapidly attacked by them, and converted into nitric acid, which, uniting with the bases present, finally produces nitrates.

The purification of sewage is, therefore, a process of destruction of this organic matter by means of bacteria, and, finally, of the bacteria themselves from inanition. It necessitates their cultivation, and a provision of the most suitable conditions for their life and propagation, until the organic matter shall be converted and the conditions of their existence shall cease. If we think of fermentation, and its cause and effect, we get an idea of the process.

Through Pasteur and others, much is already known concerning these important low forms of life. We are here concerned only with their chief conditions for action. Pasteur divided them into two classes, the aerobic and anaerobic bacteria,—that is, those which need oxygen for their growth, and those which do not. The aerobies do their best work when the sewage is exposed to air; they produce oxidation. The anaerobies do their best work when air is excluded; they produce putrefaction. A further condition of active life is a warm temperature of the sewage, although freezing temperature, while reducing the activity of the bacteria, does not destroy all of them.

The aerobic process, when applied to organic matter in suspension, is slower than the anaerobic process. It takes a long time for

solid particles of organic matter to disappear as such, when the conversion depends on the oxygen contained in the water. It takes a short time, when it is brought about by anaerobic bacteria, which produce conditions causing a liquefaction of the solid organic matter.

The reverse seems true in the case of organic matter in solution, because the aerobic bacteria, or conditions favoring a thorough aeration of liquid sewage, will remove a much greater amount of organic matter from the water in the same time than if it is left to the action of anaerobies.

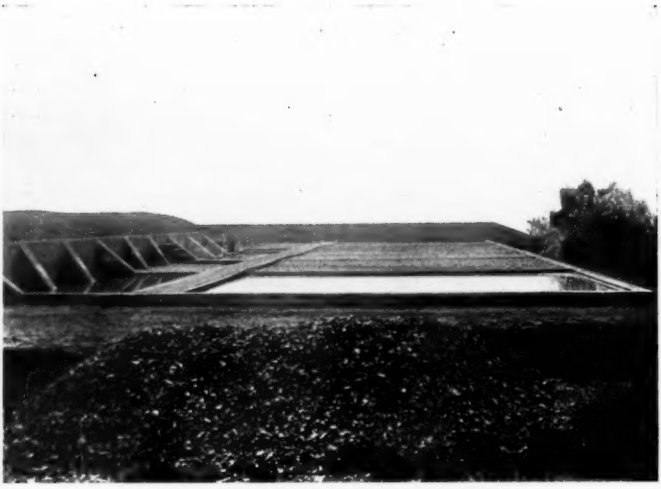
The practical application hereof is the fact that putrefaction hastens the destruction of solid organic matter, by converting it into liquids, while oxidation hastens the destruction of liquid organic matter, by converting it into soluble mineral matter So far as concomitant effects are concerned, putrefaction causes offensive odors, while the effects of oxidation are imperceptible to the senses.

After these preliminary remarks, we are prepared to examine the principal methods of sewage purification as they have been successfully practised for some time, and especially some recent suggestions that have been subjected to experiment and are now, so to speak, on trial. As the former have been frequently and fully described elsewhere, they shall be mentioned merely by reference.

The investigations of E. Frankland, Warrington, Sorby, and Dupré in England, of Schloesing, Muntz, and Marié Davy in Paris, and of Alex. Muller and others, in Berlin, first demonstrated in various ways the fact, now well established, that the purification of sewage is accomplished by bacterial action. In 1872 the Berlin Sewerage Commission reported that sewage matter was converted into nitrates, not by a simple molecular process, but by organisms always found in sewage. Early in the same decade Bailey Denton, in England, built the first artificial sewage filtration works, where the sewage was caused to filter intermittently through beds of sandy earth, in such a manner that the organic matter was converted into nitrates by oxidation within the pores of the soil.

In the report of the Massachusetts State Board of Health, dated January, 1888, it is said with reference to purifying the sewage by intermittent filtration: "At the present no one can tell, in regard to any area that may be selected, the character of the effluent water that will result from the application of sewage in large or small quantities, nor the effect of our winters nor of long storms upon the efficiency of the beds, nor the proper intervals for application. This knowledge can be obtained only by trial and careful observation."

The subsequent experiments concerning these questions, undertaken by the board and reported in 1890, demonstrated the nature of



GENERAL VIEW OF SEWAGE FILTERS AT EXETER.

the process of sewage-purification accomplished by intermittent filtration and aerobic bacteria, and gave the world some fundamental data by which it thereafter became practicable to ascertain the degree of purification that can be expected from certain porous materials, from their physical properties, such as the size of the grains, and from different methods of operating the processes. There are to day a number of sewage-disposal plants successfully operated on aerobic principles, both in Europe and America, which confirm the conclusions of the Massachusetts board.

This method of disposal is clearly practicable only in localities where a sufficient area of porous land is available, upon which the crude sewage can be spread in suitable quantity, into which it can filter with the proper velocity, and from which it can emerge as a thoroughly-purified water. There are localities where the suitable land is scarce, too expensive for the purpose, or wholly absent. In such cases other methods of disposal are necessary.

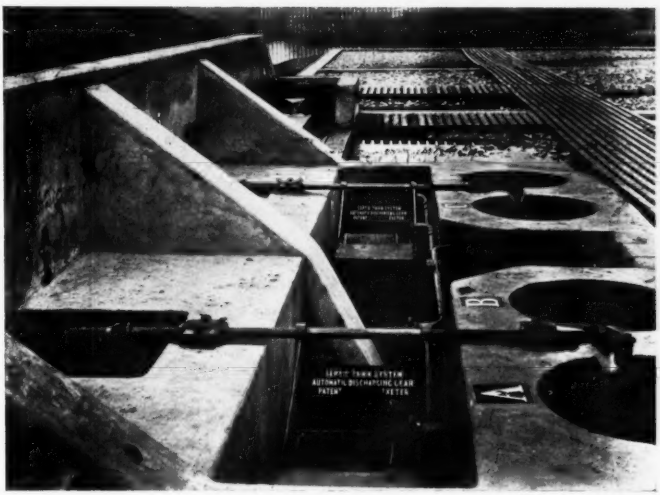
It was said above that sewage liquids are oxidized more rapidly than suspended solid matter. Therefore separation was suggested, subjecting only the clarified sewage to filtration, and thus requiring much less filter-area. The separation was accomplished in nearly all cases by a chemical precipitation of the solid particles. The principal chemicals used were milk of lime and salts of iron. The precipitated matter formed a sludge on the bottom of the settling tanks, and

at intervals had to be taken out, freed from most of its water in filter presses, and then removed.

The precipitation processes have been common in England. They remove about one-half of the total organic matter, and the purification of the remaining clarified liquid is accomplished by the aerobic bacterial process. On account of the expense of precipitating the suspended matter, and the endeavor to save money, such works have not always received the care necessary to render them inoffensive, and other ways of accomplishing the object have been sought.

Recently another method has been extensively tried and is much spoken of,—namely, the liquefaction of the solid organic matter, through the aid of anaerobic bacteria, which, it is claimed, materially reduces the expense of treatment.

In a French periodical, *Cosmos-les-Mondes* (December, 1881, p. 622, and January, 1882, p. 97), there is an article on the Mouras Automatic Scavenger, which is described as a "mysterious contrivance" that has been used for twenty years. It consists of a vault hermetically closed by an hydraulic seal. "By a mysterious operation, and one which reveals an entirely novel principle, it rapidly transforms all" the excrementitious matter which "it receives into a homogeneous fluid, only slightly turbid, and holding all the solid matters in suspension in the form of scarcely-visible filaments." The



ALTERNATING GEAR FOR CONTROLLING FILLING OF SEWAGE FILTERS AT EXETER.

SEWAGE DISPOSAL WORKS AT YEOVIL.

vault is self-emptying, and continuous in its working. "The liquid which escapes, while it contains all the organic and inorganic elements of the fæces, is almost devoid of smell, and can be received into a watering-cart for horticultural purposes, or may pass away into the sewer for use in irrigation."

Passing on to the theory of the action, it is then said: "May not the unseen agents be those vibrions or anaerobies which, according to Pasteur, are destroyed by oxygen, and only manifest their activity in vessels from which the air is excluded?" Daily observations conducted with a glass model showed that "fæcal matters introduced on the 29th of August were entirely dissolved on the 16th of September." "Even kitchen refuse, onion peelings, etc., which at first floated on the surface, descended after a time to the bottom of the vessel, and awaited decomposition. Everything capable of being dissolved acted in a similar way, and even paper wholly disappeared."

It is further said: "The principles on which M. Mouras bases the action of this machine is that the animal dejecta contain within themselves all the principles of fermentation or of dissolution necessary and sufficient to liquefy them, and to render them immediately useful in their return to the soil and without appreciable loss."

In a later article of the *Cosmos-les-Mondes* (January, 1883, p. 110), entitled "Theory and Accurate Working of the Automatic Scavenger," and written by Abbé F. Moigno, certain additional information is given, by which the proper dimensions of such a tank may be

GENERAL VIEW OF SEWAGE FILTERS AT SUTTON, SURREY.
In the background are seen the covered tanks formerly used in the chemical treatment.

ascertained. M. Mouras is reported to have made the following statements. For the complete solution of the floating solid matter a period of thirty days should be allowed. The superficial area of the tank should be $\frac{1}{10}$ metre per person. The thickness of the top layer of undissolved solid matter should not exceed 0.075 metre (say, 3 inches). The depth of the deposit is assumed as 0.02 metre (say, 1 inch). The depth of the submerged portion of the outflow pipe below the surface should be 0.18 metre (say, 7 inches).

If we assume:

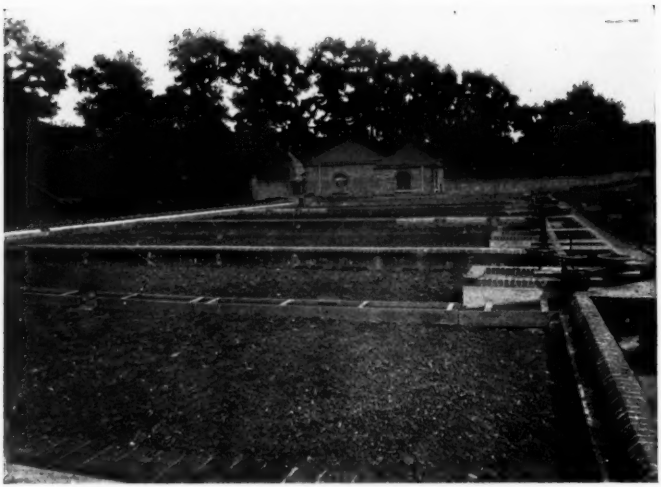
v = daily volume of excreta per person,
n = number of persons,
a = area of tank,
d = depth of tank, which should be at least one metre, if only excreta entered it,
s = thickness of floating layer of undecomposed solids,
c = thickness of layer of deposited detritus,

then the size of the necessary tank may be ascertained from the following formula:

$$a = \frac{30\ v\ n}{s}$$

$$d = 1 \text{ metre} + n\ c$$

From the description of this interesting contrivance, it will be seen that the process of anaerobic decomposition was practically applied



UPPER OR BACTERIAL BEDS; SUTTON SEWAGE DISPOSAL PLANT.
The sewage is entering the nearest filter.

many years ago. It does not seem to have been suggested, however, as a method to be adopted on a large scale, until it was introduced at Exeter, England, in 1896, by Mr. Donald Cameron, city engineer.

This plant was built to purify the sewage of about 1,500 persons. It consists of three parts:

(1) The grit chambers, where mainly road washings are retained, and from which they can be separately removed.

(2) The septic tank, in which the liquefaction of the suspended sewage matter is said to be accomplished within about twenty-four hours, and which closely resembles the Mouras scavenger.

(3) The filters, where the effluent from the tank is finally purified by filtration.

The part concerning us most at present is the septic tank. It holds one day's supply of sewage, and is about 65 feet long, 18 feet wide, and 7 to 7¾ feet deep, and is said to have treated about 50,000 imperial gallons per day.

Dibdin found in the Exeter sewage 24.5 grains of suspended matter per imperial gallon, and in the tank effluent he found only 10.8 grains; therefore 13.7 grains per gallon must have either remained in the tank as deposit or been liquefied. As, after several months, the floating scum was only 6 inches thick, and the sediment, consisting of fine matter, was mostly formed of nitrates, it is claimed that most

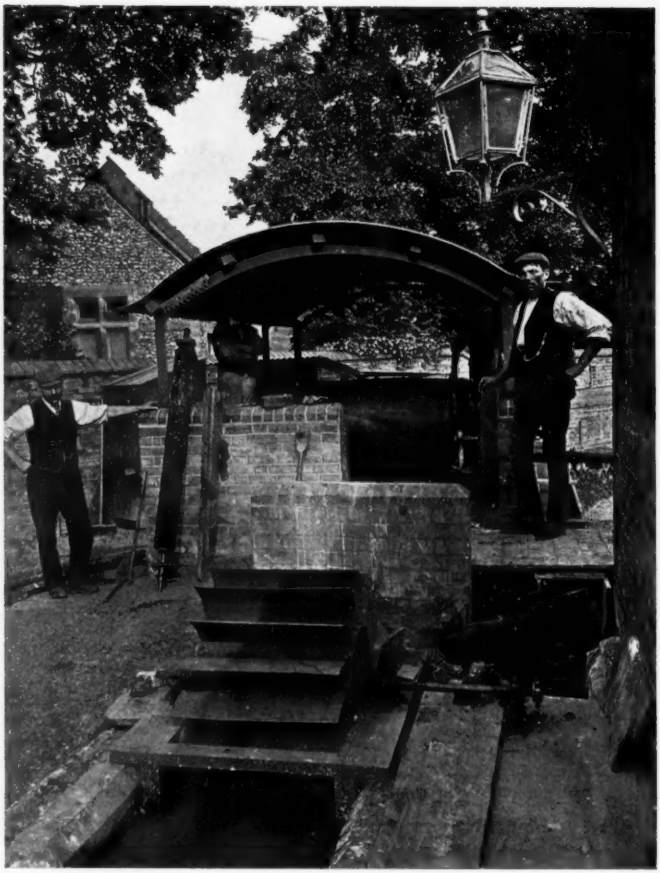
of the organic matter originally suspended must have been liquefied.

Our illustrations give several views of the Exeter works, showing the covered air-tight septic tank, the filters, and the alternating gear for controlling the charge of the filters.

Recently the Local Government Board of England made an examination of the Exeter works and a report thereon. It comes to the conclusion that, "if the septic process be adopted, a further treatment of the sewage on land will still be required, previous to the effluent being discharged into the river." It would "approve of the scheme on the distinct understanding that the city council, in adopting this system as an experimental substitute for the ordinary process of chemical precipitation, will accept the entire responsibility for the experiment, and will give an undertaking that, in the event of the process failing to give satisfactory results when applied to the sewage of the entire city, they will adopt in its place some process of treating the sewage with chemicals combined with artificial filtration." With regard to the quantity of land required, the board orders that the city provide itself for this purpose with one acre for each 2,000 of the population,—about the amount required for treating the effluent water from chemical precipitation works.

LOWER, OR "FINE BEDS"; SUTTON SEWAGE DISPOSAL PLANT.

The Exeter works have been in operation now almost two years, and the continued results will be watched with much interest.



PERFORATED SCREEN FOR REMOVING SOLID MATTER FROM SEWAGE AT SUTTON.
The screen is revolved by water power, the sewage current operating the wheel.

The septic-tank system has recently also been introduced at Yeovil. Much of the sewage contains refuse from works engaged in the manufacture of glove leather, and is said to be of an especially obnoxious character. In addition to the organic impurities, it contains arsenic and other poisons. It is reported that, notwithstanding the unfavorable character of the sewage, the treatment has been greatly facilitated by the preliminary septic process to which it is there sub-

jected. It seems from the statement that sewage containing manufacturing refuse may likewise be purified by the bacterial process. One of our illustrations shows a view of the Yeovil works.

There is little information as yet regarding the actual cost of constructing and operating works using the septic process. Semi-official statements have been made in England that, for a large population, the cost of installation is two dollars per head, and for a small population three to four dollars per head. It is not stated, however, whether this cost includes that of the necessary subsequent filtration.

There are still other methods now brought to our attention in England; of these the most prominently mentioned are the works at Sutton, Surrey.

Mainly through the suggestions and efforts of Mr. W. J. Dibdin, late chemist to the London County Council, a novel method of destroying the suspended matter of sewage has lately been adopted in Sutton. The principles which Mr. Dibdin advocates are stated as follows:

"As a preliminary it will be advisable to remove as many of the particles as possible by mechanical separation, by passing the sewage through a screen having as fine a mesh as possible. Although much has been done in this direction, . . . the best and most economical method has yet to be worked out." "What is really required is straining through a self-cleansing mesh, sufficiently fine to collect the fibers of paper, etc."

"Filtration, on biological lines, of sewage, or other foul water containing in solution but little free oxygen and a large quantity of oxidizable organic matter, means:

"(1) That the filter, by cautious increments in the quantity of effluent, which in itself contains the necessary organisms, must be gradually brought to a state of high efficiency. This condition will be shown by the existence in the filtrate of a constantly-increasing proportion of nitric acid.

(2) That the contact of the micro-organisms with the effluent to be purified must be effected by leaving such effluent to rest in the filter for a greater or less time, according to the degree of purification required, the process being analogous to that of fermentation.

(3) That, after each quantity of effluent has been dealt with, the micro-organisms must be supplied with air, which is readily effected by emptying the filter from below, whereby air is drawn into the interstices. The filter must stand empty for an hour or more previous to another filling, and a longer period of aeration—say, twenty-four hours—must be allowed every seven or eight days." (Report to London County Council, October, 1895.)

Mr. Dibdin, in 1895, made experiments with small filters and various filtering materials, on which he reported to the London County Council the following results:

"The average rate of working, including rest periods, was 411,000 gallons per acre in 24 hours. The mechanical cleansing, or clarification, is shown as follows, the figures representing units of depth required to obscure a standard mark:

Burnt ballast	1
Coke breeze	1
Pea ballast	1¾
Sand (1st portion of compound filter)	2¼
Proprietary article (2nd portion of compound filter)	2½

"The following table shows the extent of the purification effected, as indicated by the reduction in oxidisable organic matter in solution:

Burnt ballast	43.3 per cent.
Sand (1st portion of compound filter)	46.6 " "
Pea ballast	52.3 " "
Proprietary article and sand combined	61.6 " "
Coke breeze	62.2 " " "

From these results it appeared that for foul waters sand proved too fine and burnt ballast too coarse. Coke breeze seemed to unite the necessary qualifications. In the Massachusetts experiments the results obtained with sand have apparently been more favorable than in the London experiments.

A brief description of the Sutton sewage works, given by Mr. C. Chambers Smith, surveyor to the Sutton council, is about as follows. The population of the district draining into the present works is about thirteen thousand. The daily dry-weather flow of the sewage is 350,000 gallons. The sewerage works are strictly on the separate system. The accompanying illustrations exhibit the plant.

Previous to the introduction of the new works, the sewage, on arriving at the outfall, had been treated mechanically with lime and iron, in the proportions of two grains of iron and nine grains of lime per imperial gallon, and then passed into precipitation tanks, six in number. After subsidence, the supernatant water was run off upon the artificial filter or upon the land, as circumstances permitted.

The consideration of the new crude-sewage filter, or "bacteria tank," as it is there called, was commenced early in November, 1896, by using one of the precipitation tanks for the purpose. It has an area of about 183 square yards, on the floor of which was laid a six-inch main drain, with three-inch branch drains, nineteen in number, running to the side walls. The main pipe can be closed with a

valve, and shut down when the tank is being filled, and is full.

The joints of the pipes are open, and covered with the coarsest of the material. The tank is then filled with so-called ballast, consisting of broken-up burnt clay. The average depth of the ballast in the filter is 3 feet 6 inches. Care was taken to exclude the dust and whatever fine material passed through a screen of one-half-inch mesh.

The filter can hold 13,500 imperial gallons of sewage, the proportions being approximately one-third sewage and two-thirds ballast. The flow of sewage per square yard is 186 gallons per day, and, per cubic yard of the material, 139 gallons per day. At the rate per acre the daily quantity of sewage would be about 900,000 gallons.

An automatic rotary screen is used to intercept the floating paper, etc., before the sewage is applied to the tanks.

The bacteria tank is reported to have been in daily work since November 21, 1896, treating, on an average, 30,000 gallons per day. The "tank" is charged twice, or sometimes three times, a day, after passing the sewage through screens, to intercept the larger pieces of floating matter.

The time occupied in filling is about three-quarters of an hour. Care is taken to prevent the sewage from reaching the surface, by stopping the flow as soon as the sewage-level rises to within a few inches of the top of the bed; thus light is excluded. The "tank" is then allowed to remain charged for about two hours, during which time the anaerobies have their opportunity to work, after which the valve is opened and the "fermenting" sewage flows out. The time occupied in emptying is about one hour and a quarter. The "tank" is then allowed a rest of two hours, when the aerobic bacteria are supposed to do their share of the work, after which it is again charged, the cycle occupying six hours. Mr. Smith states that the material remains inoffensive.

The total quantity of sewage treated in this manner up to March 31, 1898, is given as 16,598,365 imperial gallons. Mr. Dibdin estimates that in the tank 57.25 grains of the original 60 grains of suspended matter per gallon had been absorbed, equalling 603 tons of sludge.

Three tanks filled with coarse-grained material have recently been added, constructed like the first, and it is reported that a sufficient number will be added to treat the entire sewage-flow of the city in this manner.

After the sewage has been passed through these coarse-grained "bacteria tanks," it is passed through fine-grained tanks, or filters, of which eventually eight are to be provided for purifying the entire quantity of effluent from the former.

The fine-grained filters are composed of various materials,—coke breeze, sand, gravel, and burnt ballast,—the grains of the latter not exceeding three-eighths of an inch in diameter.

The reduction of the oxidizable matters in solution is reported by Mr. Dibdin to be from about 4.54 to 1.67 grains per imperial gallon in the "bacteria tank," or coarse filter, and finally to about 0.64 grain in the fine filters, showing an average reduction of about 63 per cent. by the coarse, and a further reduction of 22 per cent. by the fine, filters, or 85 per cent. in all.

The nitrogenous organic matter, as indicated by the albuminoid ammonia, was in like manner reduced 58.45 per cent. in the coarse, and 20.09 per cent. in the fine, filters, or 78.54 per cent. in all.

The matters in suspension in the crude sewage are reduced from 60.03 to 2.78 grains per imperial gallon in the coarse filter, and still further to 0.725 grains per gallon in the filtrate issuing from the fine coke-breeze filter.

While we cannot doubt the correctness of the analyses given to the world by Mr. Dibdin, the time which has passed since the Sutton filters were first operated is hardly sufficient to give results which can be permanently relied upon; nor does the element of cost of construction and annual operation seem to have been definitely determined as yet.

There can be no doubt that this process will yield pure water, if the applied sewage is previously freed from suspended matters, and ir there is not enough poisonous matter in the sewage to destroy the useful bacteria. The difficulties which may be expected in the Sutton process lie in the possible gradual filling-up of the filters with slowly-oxidizable vegetable matter not strained out by the screens. It is difficult to operate economically a strainer fine enough to keep out fibrous vegetable material. A plant similar to the one in Sutton has been operated at Leeds, and there it has been found that the sludging-up of the beds was one of the chief difficulties. It was also found that, after a fortnight's rest of a filter, the flow was materially increased. But a permanent relation between the length of time during which the retained fibrous sewage matter is removed by oxidization and the amount of sewage that can be permanently filtered per square foot of filter area has not yet been found.

All we can safely say at the present time is that both the Exeter and Sutton experiments not only are interesting, but promise to improve the present methods of sewage-disposal where suitable land for slow filtration is not available, although perhaps the improvement may not be as great as anticipated by the promoters.

Still another suggestion has recently been made by Mr. Walter M.

Ducat, who recommends a number of artificially-constructed filters, resting one over the other in such a manner that a continuous aeration of the entire filter, from top, bottom, and sides, is supposed to take place automatically. The beds are so arranged that the coarse material is uppermost, and the finest at the bottom. Whether or not any works have been constructed on this principle, except for a short experiment on a small scale, does not appear. But it may safely be stated that, unless such a filter were charged with a clarified effluent, or, in other words, sewage entirely freed from suspended matter, it would sooner or later become filled up and cease to operate.

To return to our introductory considerations, it appears that, with a limited amount of land, permanent success in purifying sewage can be accomplished only by a prior separation of the suspended and dissolved organic matter. Organic matter in solution can be thoroughly purified by aerobic bacteria, and in large quantities per acre, in properly-devised filters of sand, coke breeze, or similar porous and permanent material, operated intermittently. Undoubtedly, also, some fine fibrous or globular nitrogenous matter may also be removed by this relatively rapid process. But the organic matter in suspension requires a preliminary separate treatment, either, first, by a system of chemical precipitation, or, secondly, by a system of liquefaction as accomplished in the septic tank, by which the quantity of sludge is at least very greatly reduced, or, thirdly, by a preliminary very fine screening with a subsequent liquefaction of the remaining suspended matter in a so-called bacteria tank.

Whether the first, second, or third method will prevail in the future depends largely on the question of cost of obtaining satisfactory results which may be ascertained from the experience now being gained.

In conclusion, I beg to render my thanks to Mr. A. S. Crane, C. E., who has furnished illustrations accompanying this article, to Mr. Donald Cameron, and to Mr. W. J. Dibdin, from whose reports numerous extracts have been made.

THE APPLICATION OF ALTERNATING CURRENTS TO ELECTRIC TRACTION.

By Charles Henry Davis and Howard C. Forbes.

II.

IN the last number of THE ENGINEERING MAGAZINE we discussed, in a general way, the question of transmitting electric power from a waterfall, or other cheap source, to a steam railroad, by means of the alternating current, and the operation of such a road by electric motors; and we showed:

(1) That the alternating-current motor of to-day cannot be directly applied to operating railroad trains, either on the axles o the cars or at the head of the train as a locomotive, because of the difficulties in starting under load and in controlling the necessary variations in speed.

(2) That the alternating current can be indirectly applied to operating railways, because of the facility with which we can transform it to high potentials for long-distance transmission.

Let us, now, consider in detail the indirect application of alternating currents to railway work. We shall describe three general cases, and then consider specifically the problem of a new road built for very high speed, with trains at frequent intervals, comparing the relative first cost and operating expenses, assuming electric power to be obtained from a cheap source at a distance, with the corresponding charges, and assuming the usual power stations located at intervals along the road.

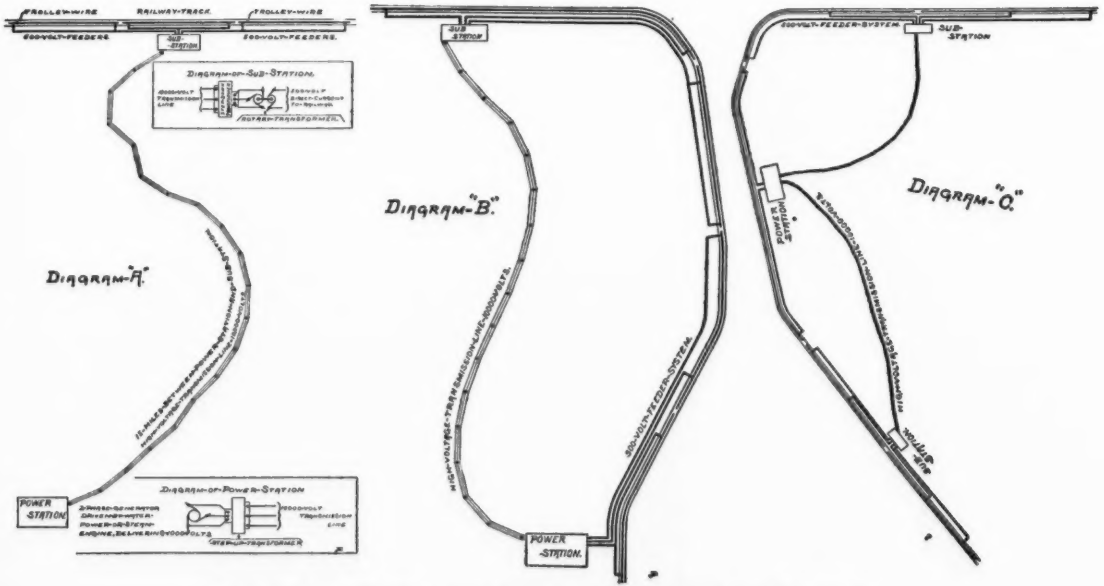
In the use of alternating currents in railway work there are three typical cases. These are illustrated by the diagrams as follows:

(1) Diagram A. Where the source of power is located a considerable distance from the line of railway.

(2) Diagram B. Where the source of power is located at one end of the railway line.

(3) Diagram C. Where the source of power is located at the middle of the railway line, or section thereof.

The first case (Diagram A) arises where the entire line of railway is located a long distance from the water-power which it is desired to utilize. This is the most common case, especially in street railway work, for many of the smaller water-powers and some of the larger are now being developed, and their power transmitted 15 to 20 miles or even more, by means of two- or three-phase alternating electric



DIAGRAMS SHOWING ARRANGEMENTS FOR VARIOUS LOCATIONS OF POWER STATIONS.

currents. The second case (Diagram B) also occurs with street railways where the track runs to some point near a water-power. At the power station, in this case, is located a generator which delivers both alternating and direct current; this generator is similar in construction to the "rotary transformer," except that it is driven by a water wheel. The direct current is applied immediately to the feeders and trolley wire for that portion of the road which lies near the power station, while the alternating current goes to the step-up transformer which raises the voltage for transmission to the sub-stations near the other parts of the line. At the sub-station the method is similar to that already described, the current passing to the step-down transformer and being changed to direct current by the rotary transformer as before. The third case (Diagram C) represents a method that can be used in operating a long line of steam railroad by electricity. The road could be divided into sections with a main power station in the center of each section, if the power were to be derived from coal in the usual way. These sections could then be divided into sub-sections, each with its sub-station, and the power transmitted from the main station to the sub-stations by alternating current at high voltage. At the sub-stations the alternating current could be transformed to direct current suitable for use by the railroad motors, as already described. The sub-sections nearest the main power stations could be operated directly from these stations, either by the use of generators delivering both alternating and direct currents, or, if a large amount of power were required, by separate direct-current machines.

If a steam railroad were operated by electric traction, the method of applying electricity along the line would probably be that shown by Diagram A, where a cheap source of power located at a distance is utilized, or that shown by Diagram C, where the power is generated near the railroad by the use of coal. The question arises, therefore, under what conditions would the cheap source of power be used, and what are the limits of its application. As we have pointed out, the tendency of many writers on this subject is to consider that the cheap source of power, coupled with alternating-current transmission at high voltages, will solve the problem of electric traction for steam railroads. This may prove to be so in the future, when we are able to use the alternating-current motor without conversion and multiphase currents at much higher pressures than are now feasible,—say, one or two hundred thousand volts.

To enable us to intelligently compare the relative first cost and operating expenses of the two methods,—*viz.*, "cheap source" of power located at a distance, and the application of power from points

along the line of railway,—we shall consider a definite case, chosen with a view to deducing as general conclusions as possible. We assume, therefore, a proposed road connecting New York harbor with Philadelphia, an outline of which was given in THE ENGINEERING MAGAZINE (October and November, 1897) under title of "The Enormous Possibilities of Rapid Electric Travel." This case is one where electric traction is the only satisfactory or profitable solution. For the purposes of our comparison, we shall assume that such a road is feasible both from a physical and a commercial point of view, and we shall show the relative cost of applying electric power under two conditions,—namely, Case 1, Diagram A, where the source of cheap power is "available within a few hundred miles of a trunk line of railway," and Case 3, Diagram C, where power stations are located in the middle of various sections of the same trunk line. We shall show how fallacious is the usual assumption that, with our present appliances and knowledge, the utilization of a "cheap source" of power results in greater economy than the use of power stations located as close to the application of power as possible; and we shall do this by giving the "cheap source" the benefit of every doubt.

Diagram D shows the layout of the railroad and feeder lines for the former case, where a cheap source of power is utilized, and Diagram E shows the layout for the latter case, where the power is generated by power stations located at intervals along the railroad.

We assume the following conditions:

Case 1 (Diagram D):

a. Unlimited amount of water power.

b. Two sources of power each, 100 miles from the line of railway (85 miles long) and dividing same into ¼, ½, and ¼.

c. Development of these water powers to cost no more than eleven power stations in Case 3 (this is highly unlikely, but favors Case 1 as against Case 3).

d. Three-phase alternating current of 20,000 volts to be used from source of power to sub stations, and 1,000 volts direct current from sub-stations to railway motors (this favors Case 1 as against Case 3).

e. Sections 8.5 miles long (44,892 feet).

f. Sub-sections 11,223 feet long, 30 in all, each with a sub-station rotary transformer plant.

g. Three tracks, minimum headway on each, three minutes; trains of five cars each, being 8.5 miles apart.

h. Each train will require not more than 10,000 i. h. p. at the stations, under economical conditions.

i. Each sub-station an economical rating of 20,000 i. h. p.

j. In either case feeder lines along the line of railway equal each other (this also favors Case 1 as against Case 3).

k. All other conditions to be the same as assumed in the article, referred to above, entitled "The Enormous Possibilities of Rapid Electric Travel."

Case 3 (Diagram E):

a. Eleven power stations, one for each section and one at each end of the line, 8.5 miles apart, each supplying current to 3 sub-stations with rotary transformers—sub stations 2.125 miles apart.

b. Cost of the eleven power stations, each 30,000 i.h.p. economical rating to equal the cost of developing water powers in Case 1 (favoring Case 1 as against Case 3).

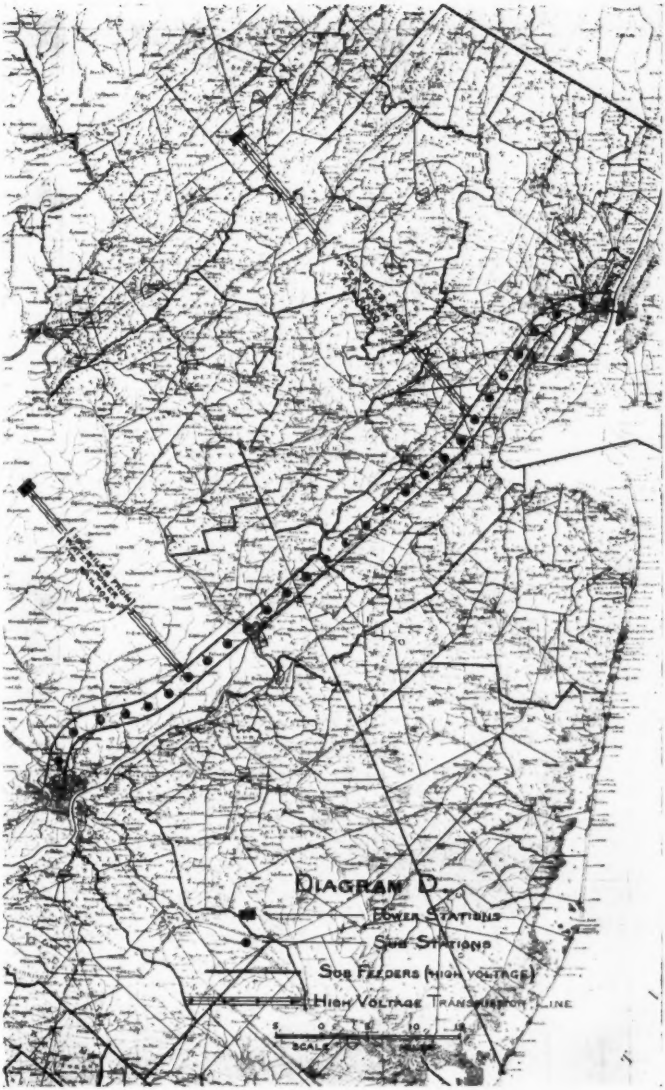
c. Three-phase alternating current of 10,000 volts from power stations to sub stations, and 1,000 volts direct current from sub-stations to railway motors (this favors Case 1 as against Case 3).

d. All other conditions similar to *e*, *f*, *g*, *h*, *i*, *j*, and *k*, of Case 1.

From diagrams D and E it will be seen that the track, third rail, direct-current feeders, sub-stations, etc., will be the same in both cases. The amount of copper in the high-voltage sub-feeders in Diagram D, which run from the point where the transmission line strikes the road to the sub-station either way, would be greater than that in the high-voltage lines from the power stations to the sub-stations in Diagram E. The main point to consider, however, is the high-voltage transmission lines themselves (Diagram D) from the water powers to the point where they strike the line of the railroad. Under the above conditions, if the interest on the additional investment for these transmission lines from the "cheap source" of power to the railway line in Case 1 exceeds the difference between Case 3 and Case 1 in cost of power delivered to the sub-station supply feeders, then it is unprofitable to utilize the "cheap source" of power.

Our calculations, therefore, can be confined to the cost of the two transmission lines in Case 1, each 100 miles long, from the two sources of water power to the line of railway, and the difference in the cost of producing power, at the sub-station supply feeders. If the interest on the former exceeds the difference in the latter, then it is unprofitable to use the "cheap source" of power.

In making the calculations, every care has been taken to be fair to the distant source of power, and wherever then is any room for doubt, the "cheap source" has been given the benefit.



D. RAILWAY BETWEEN NEW YORK AND PHILADELPHIA. DISTANT WATER POWER.

We have figured the pounds of copper necessary as follows:

$$\text{Circular mills (Diam. of wires squared)} = \frac{\text{Current} \times \text{Distance in feet} \times 20}{\text{Volts lost in line.}}$$

$$\text{Current} = \frac{\text{Watts}}{\text{V}} = \frac{\text{Horse Power} \times 746}{\text{Voltage of transmission.}}$$

$$\text{Pounds of Copper} = .016 \times \text{cir. mills} \times \text{miles.}$$

Therefore:

$$\text{Lbs. of cu.} = 1{,}262{,}000 \frac{\text{H.P.} \times \overline{\text{Miles}}^{2}}{(\text{Voltage of Trans.}) \times (\text{loss in volts})}$$

For 100 miles transmission at 20,000 volts, and a loss of voltage in the line of 20 per cent, or 4,000 volts, the formula becomes:

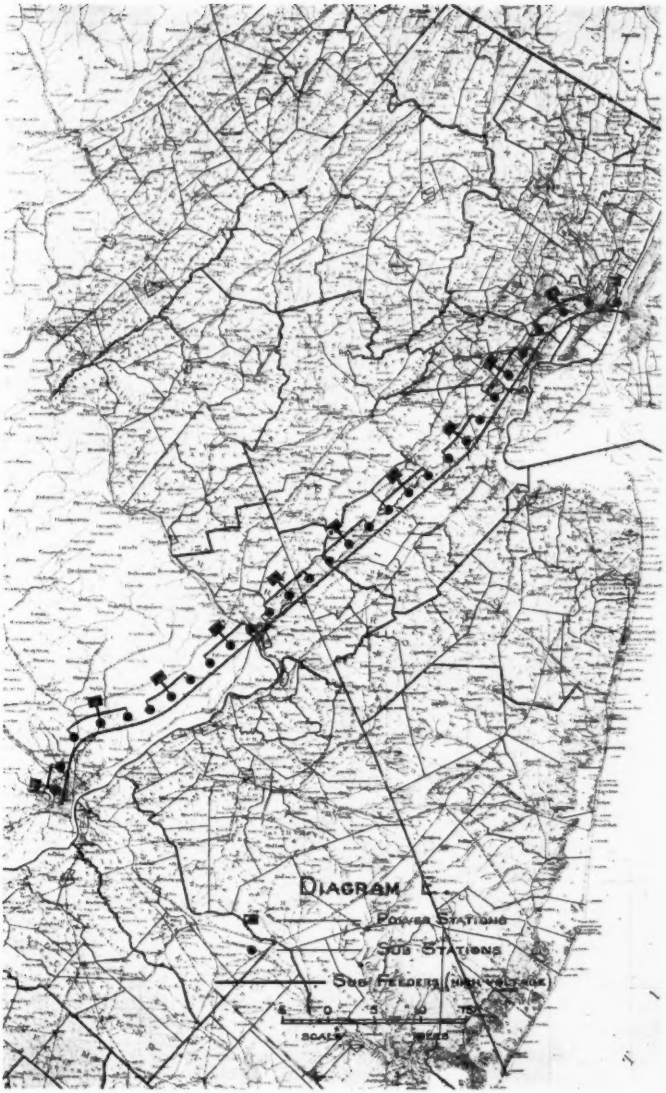
$$\text{Lbs. of copper} = 158 \times \text{H.P.}$$

This is correct for direct current. For alternating, the inductive loss would increase the amount of copper required to obtain the same total percentage loss, or, if the same amount of copper is used, would increase the total percentage loss. At the same time there would be a saving due to the three-phase wiring system, which would partly counterbalance the loss due to induction. The actual formula would have to be deduced for each special case of wiring, but, on the whole, the above formula, used directly, is sufficient for our purpose.

As the horse power to be transmitted equals 412,500 at 20 per cent. loss (330,000 h.p. delivered at the railway line), the total amount of copper necessary is 65,175,000 pounds.

We therefore make the following comparison:

	Case 1.	*Case 3.*
Allowable loss in pressure from water powers to railway line	20%	.....
Total h.p. to be delivered to railway line at supply feeders of sub-stations	330,000	330,000
Total h.p. at source of power	412,500	330,000
Number of power stations	2	11
Total h.p. at each power station	206,250	30,000
Total distance, in miles, power is transmitted from each station	100	0
Pressure at source of power (volts)	20,000	10,000
" " railway line (volts)	16,000	10,000
" lost in line (volts)	4,000	0
No. of sub-stations supplied from each source	15	3
Average length of sub-feeders (miles)	10.625	4.25
Number of sub stations on each group of sub-feeders	7.5	3
Pounds of copper in transmission line	65,175,000	0



E. RAILWAY BETWEEN NEW YORK AND PHILADELPHIA. LOCAL POWER STATIONS.

We give below a tabulated estimate of the cost of our proposed transmission line.

Right of way—two strips 100 feet wide and 100 miles long = about 2,500 acres @ $1,000, average.....	$2,500,000
Engineering, 2% on $15,000,000.....	300,000
Clearing 600 acres @ $100.....	60,000
Bridges, viaducts, or sub-marine cables, say (an approximate estimate).....	1,500,000
Fencing.....	200,000
Crossings, say 120 @ $1,000.....	120,000
Signals for guarding and repairing 200 miles @ $1,000	200,000
Telegraph 200 miles @ $1,000.....	200,000
Narrow-gauge repair track and equipment, 200 miles @ $5,000.....	1,000,000
Feeders 65,175,000 pounds @ 15c in place.....	9,780,000
Pole line, 11,000 poles set in concrete @ $100 each...	1,100,000
Discount on $25,000,000, 3% 100-year bonds.....	1,250,000
Interest on bonds to opening of road, say, 10 years of construction, averaging $2,500,000 per annum @ 3%.....	4,125,000
Taxes to opening of road, assuming ¼ assessment and 2% rate.....	1,375,000
Office expenses, salaries, etc., to opening of road, 2% on $15,000,000.....	300,000
Contingent, etc., not itemized, to opening of road, 5.2%	1,300,000
Total cost.....	$25,310,000

To the total cost of transmission line, amounting to $25,000,000 (in round numbers), should be added the additional cost of developing the two water powers to 412,500 h.p. as against 330,000 h.p. in the eleven steam power stations along the railway line; also there should be added the additional cost of feeder lines from the two railway terminals of the transmission lines to the sub-stations, as against the cost of feeders from the steam power stations to the sub-stations. While these two items would undoubtedly amount to several million dollars in the case under discussion, we have omitted them, owing to the difficulty of estimating the former without accurate surveys of special localities to be developed; their omission favors Case 1. So far we have an excess in first cost of $25,000,000 against Case 1 as compared with Case 3.

We give below a comparison of the running expenses under the two conditions, based upon the calculations in "The Enormous Possibilities of Rapid Electric Travel" already referred to, the items

being given in percentages of the total cost per car-mile run, and being reasonable averages.

	Case 1.	*Case 3.*
Repairs of N.G. track on transmission line r. of w.	1.0%	.....
Repairs of fences, crossings, etc., on transmission line r. of w.	.1%	.....
Repairs of feeder lines on transmission line r. of w.	6.0%	.....
Renewals of poles and insulation on transmission line r. of w.	1.5%	.....
Renewals of feeder on transmission line r. of w.	1.0%	.....
Repairs of bridges and trestles on transmission line r. of w.	.3%	.....
Repairs of buildings on transmission line r. of w.	.1%	.....
Repairs of signals and telegraph on transmission line r. of w.	.5%	.....
Fuel for power stations	.....	8.0%
Water supply	.....	1.0%
Oil and waste	.5%	1.0%
Repairs of power stations	2.0%	4.0%
Power station wages	2.0%	4.0%
Average h.p. developed at source of power	412,500	330,000
Total car-miles per annum	43,435,000	43,435,000
Total cost per car-mile	.....	15 cts.
Add for excess power developed by water powers (25%) say	3.0%	.....
All other items being the same, the reader being referred to the articles already quoted	.....	.....

From the table above, it is seen that the items added to the cost per car-mile by the use of water-powers located 100 miles away about balance the greater cost of fuel, water, oil and waste, repairs to power stations, and power station wages, where the stations are located close to the tracks and operated by steam power (each amounts to 18%). Hence the total expenses would be practically the same for each case. As the transmission lines cost $25,000,000, the interest thereon is the total increase in the expense of utilizing the water-powers instead of steam power plants. This interest may be figured at 3 per cent. ($750,000), 4 per cent. ($1,000,000), 5 per cent. ($1,250,000), 6 per cent. ($1,500,000), or even 10 per cent. ($2,500,000), as the

case may require or good judgment dictate. The use, therefore, of these supposed water-powers would decrease the earning capacity, instead of increasing it.

Let us, for the moment, assume that our calculations of the operating expenses with the use of water powers is inaccurate, that in many of the items there is a greater saving, and that those having no counterpart in the other column can be materially reduced.

We give the following tables:

Interest.	*Car-miles.*	*Total Interest.*	*Saving in Cents per Car-mile which must take place to allow the investment.*
10%	43,435,000	$2,500,000	5.81 cts.
6%	"	1,500,000	3.68 "
5%	"	1,250,000	2.90 "
4%	"	1,000,000	2.32 "
3%	"	750,000	1.74 "

But 18 per cent. (total of per cent. items in former table) or 15 cents (assumed cost per car-mile) equals 2.7 cents; so that, at the five interest rates, we can afford to have our figures wrong by:

With interest at 10%—266% of 18% = (38% of total)
" " " 6%—133% " " = (24% " ")
" " " 5%—105% " " = (19% " ")
" " " 4%— 83% " " = (15% " ")
" " " 3%— 64% " " = (11% " ")

It is unlikely that we have made any such error as would be necessary to show that, even with money worth only 3 per cent., it would pay to utilize the water powers in the case we have discussed. Furthermore we have favored Case 1 in every way, and more especially by comparing a 20,000-volt system with one of 10,000 volts.

Had we used higher voltages on our transmission line, the copper would have cost:

At 50,000 volts—63 × H.P. = 10,310,000 lbs.—$1,555,000.
100,000 " —25 × H.P. = 2,600,000 lbs.— 390,000.

By using higher voltages some items of the first cost would be slightly reduced, but, as these constitute more than 60 per cent. of the total cost whereas copper constitutes less than 40 per cent., a reduction in the latter increases the percentage of the former, although reducing the actual amount. Using 100,000 volts, the first cost would not be less than $10,000,000; the interest on this at 3 per cent. equals $300,000, and the corresponding saving in cents per car-mile which must take place to allow this investment equals 0.7 (cents); therefore 25 per cent. of 18 per cent. (4.6 per cent. of total) can be allowed, even in this case, for errors in our calculation.

The case we have discussed shows conclusively that it would not

pay to utilize the water powers. But, it may be said, this covers only one problem. While this is true, nevertheless this problem is one chosen to enable us to arrive at a general conclusion; for we are dealing with a very large amount of power at a comparatively short distance. The larger the power to be used, the more likely it is that a cheap source will prove profitable; the greater the distance over which the power must be transmitted, the less likely it is that a cheap source will prove profitable.

While, undoubtedly, the utilization of water power by long-distance transmission does, in some cases, prove more profitable than other sources, and while, in the future, they may prove even more so, yet to-day the investor should be cautious about believing that a particular one will return the profits contemplated or promised. The future will see, as the past has seen, many improvements along the lines suggested herein, and these will help towards a more favorable solution than we can see to-day.

THE BAKU PETROLEUM DISTRICT OF RUSSIA.

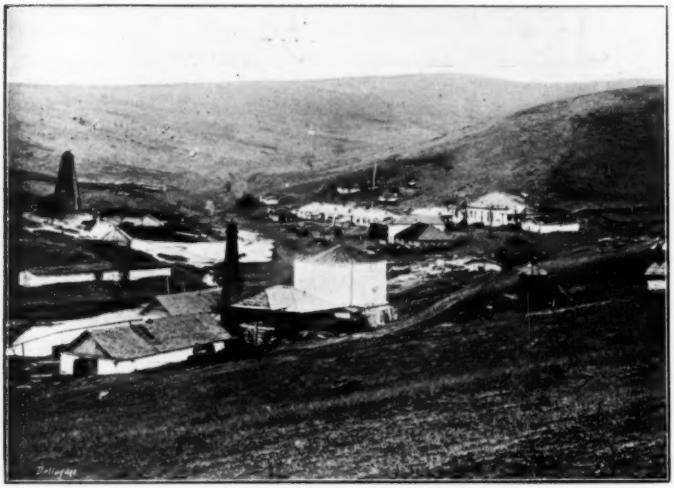
By David A. Louis.

THE enormous extent and importance of the oil-region of south-east Russia was touched upon by me in a recent contribution to the editorial department of THE ENGINEERING MAGAZINE. The magnificent programme thoughtfully arranged and thoroughly and successfully carried out by the generous Russian hosts of the Seventh International Geological Congress afforded an opportunity to judge concerning the geological and other features associated with the presence of petroleum in those districts, and to form some idea of the present day magnitude and character of the world-renowned industry so long established at Baku.

On the way to Trans-Caucasia we had passed over the Caucasus mountains from Vladikavkaz to Tiflis, following the Georgian military route; and during our progress we not alone enjoyed the impressive scenery, but also examined the interesting geological structure, acquiring in this way a preliminary insight into the age of the district we were about to visit. After a brief, but agreeable, sojourn, we left that quaintly attractive city, Tiflis, in the evening, by special train, for Baku, and, on awakening in the morning, got the first indications of the great changes that awaited us. We were travelling northward instead of eastward; the river Kur, which we had hitherto followed, had disappeared from view; the mountains had dwindled into comparative insignificance; the fertile valleys had given place to barren plains; the trains of oxen ploughing were no longer to be seen, but were replaced by caravans of camels toiling slowly along; and frail carts on very high wheels took the place of the sturdy, stumpy vehicle of Tiflis and its neighbourhood. Such things as these, and an occasional village consisting of a small cluster of square, white, flat-roofed, squat houses, or, rather, huts, with curious domed chimneys, and the groups of queer-looking people about, kept my attention attracted; then the Caspian came into view, and finally a distant forest of derricks announced our proximity to the famous oil region. On arriving, we found we had covered the distance between Tiflis and Baku, 326 miles, in 15 hours.

The tour of inspection arranged included visits to refineries, to the Bili-Eibat oil field, to the Saboontchi, Balakhany, and Romany oil-fields, and to the Sourakhany district,—all on the Apsheron peninsula.

The city of Baku is the great centre for oil-refining and export; we had immediate evidence of the export trade in the multitude of long lines of tank-wagons accumulated in the extensive railway yard and in the numerous storage tanks visible in our immediate vicinity, while a short drive, bringing us in view of the Black and White Cities, revealed the industry itself. Here there was considerable evidence of oil-distilling on a large scale, evidence too that appealed to every human sense. Hissing, thudding, rippling sounds assailed the ear; stills, condensers, tanks, vats, pipes (of all sizes, in all directions, over head and along the ground), buildings of graduated height, mud, black mud, black iridescent puddles, chimneys, and steam obtruded themselves on the vision, when the eyes were not rendered useless by dust; then, too, everything reeked of oil and felt greasy; and not only was the sense of smell violently attacked, but the palate also had its quota of the peculiar attributes of the atmosphere. In spite of all these unattractive elements, the busy aspect of the scene was exhilarating, and the various distilling apparatus were keenly inspected. The agitation of the oil with acid to remove objectionable constituents was eagerly watched, in order to see the air injected at the bottom of the great vats and cause the desired turmoil, and then the similar treatment with alkali, to remove the acid, was looked into. We admired the placidness reigning in the settling-tanks, where the oil was separating from the water previous to transference to one of the many capacious storage-tanks for refined produce. Of the distilling appliances the continuous distillation plant is the most impressive. The oil enters the end still of a series of stills, and, flowing from one to another, is exposed in each to an increased temperature, nicely regulated by adjusting the supply of liquid fuel and air used for heating the stills. Ultimately the residue of the oil passes out at the last still. Each still is provided with its steam superheater and with its condenser, the steam superheater providing steam at the required temperature to aid the separation of the volatile portions in each separate still, the condenser furnishing the necessary cooling to bring these volatile portions to the liquid state. There are steam pipes, water pipes, oil pipes, and double valves to each, and then a valve at the lower part of each still for draining out residual oil, so that any one still can be isolated, drained, cleaned, or repaired, without stopping the others. After inspecting arrays of superheaters with the arrays of the more stalwart stills and condensers alongside, making great ugly avenues, and a veritable complexity of pipes and valves, it is a relief to see that it all comes right in the end. This is discovered on entering the receiving-house. There vast numbers of pipes converge, there the various distillates arrive at the end of their journey, there the various residues



GROSNY. OIL WELLS AND LAKE OF OIL.

are delivered, there the water from the condensers and the water that has become mingled with oil have to come. Each oil, or water, as the case may be, comes along, and from its own special pipe; and in this house each is directed in one of the many channels provided, which conducts it to its destination. Some products are mixed by directing them into the same channel; some are destined for further treatment by distillation; some for chemical treatment; some for the market. The distillations and the disposal of the products are well managed at Baku, and leave a very pleasant impression from a technical point of view. Baku mainly busies itself with the manufacture of four products,—kerosene, lubricating oils, benzine, and astatki. It exports these and some crude oil, leaving the purchaser to make the various modifications and admixtures required for the various petroleum preparations. We had an opportunity of examining the products in various stages, from the crude oil to the finished state. They were displayed for our benefit in glass jars, and greatly enhanced our appreciation of the advantages derived from the various treatments of the Baku oil, helping to explain to the uninitiated why the imposing sulphuric acid and alkali works were a desirable adjunct to the refineries.

In the whole district there are more than a hundred refineries, some treating crude oil for kerosene only, some treating crude oil for

kerosene and astatki for lubricating oils, some for lubricating oils only, some for benzine alone, some for benzine and lubricating oils, and some for distilling tar. Then, various stations for storing kerosene and astatki make up the complement of establishments. These establishments deal daily with about 28,000 tons of crude oil for kerosene, of which 3,750 tons is treated in some 370 intermittent stills, and 24,250 tons in some 450 continuous stills arranged in 67 batteries in 48 refineries. Some 160 intermittent stills deal in 24 hours with 1,610 tons of astatki for lubricating oils, and 700 tons of the same material is treated during the same period, for the same purpose, in 37 continuous stills arranged in three batteries; moreover, some 400 tons of gasoline are treated, in the day, in intermittent stills, for benzine, of which they yield 112 tons. Altogether, there are abont 820 kerosene stills at work, with a possible maximum output of 9,510 tons of kerosene in 24 hours, or more than 3,200,000 tons a year, which, however, is not attained, as other appliances in the district are not equal to dealing with so great an amount. The appliances referred to are boilers and the various tanks and reservoirs for holding unrefined and refined products, for the treatment with acid and alkali, for settling, and for astatki. Yet the total number of these is prodigious, as may be gathered from the following table:

	Number.	Capacity in tons.
Tanks of all kinds for kerosene.....	953	429,225
" " " " " lubricating oils...	560	44,445
" " " " " benzine.....	116	24,104
" " " " " astatki.....	344	2,988,523
Boilers.....	544	13,567 h. p.

The storage-capacity for refined products alone is as follows:

	For refined kerosene.	For refined lubricating oils.	For refined benzine.
Capacity of tanks in tons..... ..	307,968	20,328	1,159
Number of tanks.....	234	91	22

The yearly output from the refineries, in tons, is given below, together with the figures for ten and twenty years ago:

	Kerosene.	Lubricating oils.	Benzine.	Astatki.
1896.....	1,409,424	139,494	2,705	4,758,142
Ten years ago.....	720,000			
Twenty years ago....	97,550			

These figures do not include losses by waste and leakage; they show that the Baku petroleum industry is increasing, and, as a matter of fact, it would advance still further were there greater facilities for distribution; there are not sufficient tank wagons or pipe lines.

Of the output Nobels produce 286,205 tons of kerosene. No

other manufacturers approach them, the two firms next to them producing 96,000 tons each. It is noteworthy that 5,431,600 tons of crude oil were used in the production of the 1,409,424 tons of kerosene; that is, burning oil amounted to only 25.51 per cent. of the total produce, instead of 27 per cent. in 1895, 24 per cent. in 1894, and 30 per cent. or more in all previous years. As a matter of fact, the output of kerosene in Baku is diminishing, and that of astatki increasing; this is due to difficulties encountered in the disposal of kerosene, such as competition from other petroleum-producing countries, as well as the dues that have to be paid on kerosene in Russia itself, while no

AN OIL WELL AT GROSNY.

dues are enforced on astatki. Moreover, the use of the latter is being much extended in that country, and is highly appreciated as a fuel, as, in fact, it should be. The consequence is that the production of this commodity in Baku is strenuously forced by limiting distillation and by admixture of various intermittent oils, or even crude oil, with the actual residues,—practices that raise the yield of astatki, but at the expense of the quality, introducing properties undesirable in a liquid fuel. There is, however, a market for some of the heavier distillates, and therefore they continue to be produced and sold; thus the oils of a specific gravity of 0.860 to 0.890 become solar oil, and, when refined,

are used in lamps with special burners, and, in the unrefined state, as gas-enrichers. Then come the series of lubricating oils: spindle oil, with a specific gravity of 0.890 to 0.900, flashing at 150° Centigrade, or above; engine oil, with a specific gravity of 0.900 to 0.910, flashing at 180° or above; and cylinder oil, with a specific gravity above 0.910, flashing at 210° Centigrade. These bring fair prices, and as much as 144,000 tons of lubricating oil in a year have recently been produced from 17 refineries.

Last, but not least, a special word of gratification must be expressed in connection with the great and imposing pumping installations; it is really most attractive to see these busy assemblages of pumps of many types and varying sizes, dealing, as they do, with oils of all gravities, with water and with air, in millions of tons. One is not surprised to learn that there are 1,100 pumps at work in Baku. Many of the visitors became acquainted for the first time with the vast and interesting operations that the oil had brought into existence, and an inspection of the sources of this valuable material was consequently undertaken with considerable eagerness; for, in addition to this factor, there was a very interesting geological problem to investigate, of which, too, our Russian *confrères* had supplied a solution. We had satisfied ourselves as to the tenability of part of the solution offered, during our journey across the Caucasus, and by some special excursions in Trans-Caucasia, which put us in a position to accept many general statements that could not be verified by actual inspection during the limited time of our visit.

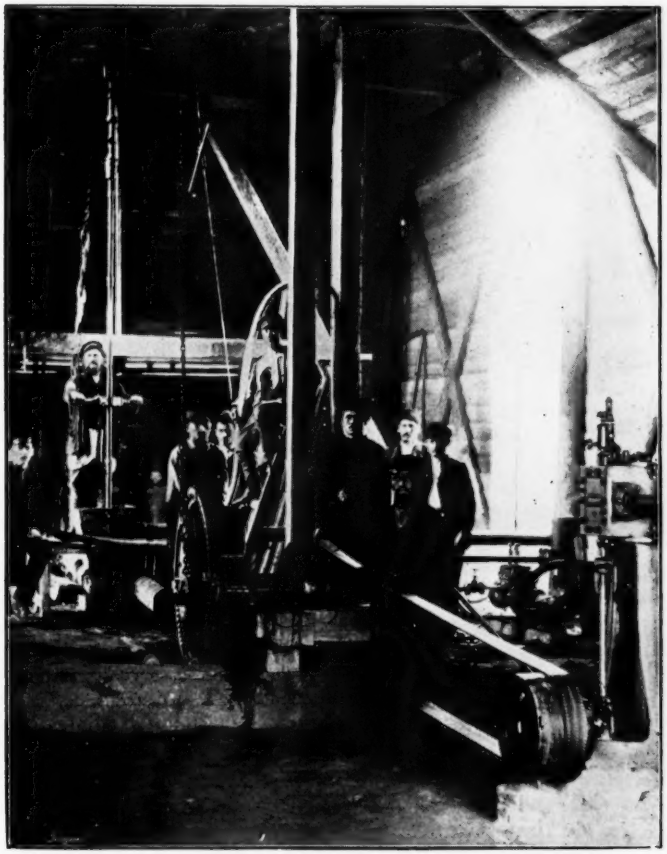
Our first visit was to Bili-Eibat. It lies in the same bay as Baku, and a little more than three miles south of that city. We reached it by boat, which gave us an opportunity of seeing the character of the surrounding country. The main feature is an escarpment trending southward, but taking a curved course, bearing south-east and terminating, as far as our field of vision extended, in a cape at the south-western extremity of the bay. On a promontory in the low-lying ground between this escarpment and the bay numerous derricks indicated what was going on. But, approaching from the sea, earlier evidence of the presence of oil-bearing strata below the surface of the Caspian sea was forthcoming in the form of briskly bubbling gases, giving the water the appearance of vigorous ebullition. There were several such centres, and, by throwing lighted tow into such a centre, ocular demonstration of the character of the gas was acquired. The faintly-luminous, flickering flames dancing about on the ruffled surface of the water presented a curious and weird appearance.

We were soon in a position to gather that the Bili-Eibat oil-field was situated at the summit of an anticlinal fold, evidently dipping

under the sea eastward, and very probably also northward and southward on the eastern side, while the whole of the western side, from north to south, is covered and encircled by the rocks and escarpment already referred to, which consists of a continuation of the Aralo-Caspian limestone upon which Baku itself is situated. Borings indicate that the strata forming the anticlinal consist of oligocene beds of oil-bearing sands over clayey beds, the oil-bearing sands coming to the surface at many points in the bay and below the surface of the water. The whole valley has been formed by the disruption and erosion of oligocene beds.

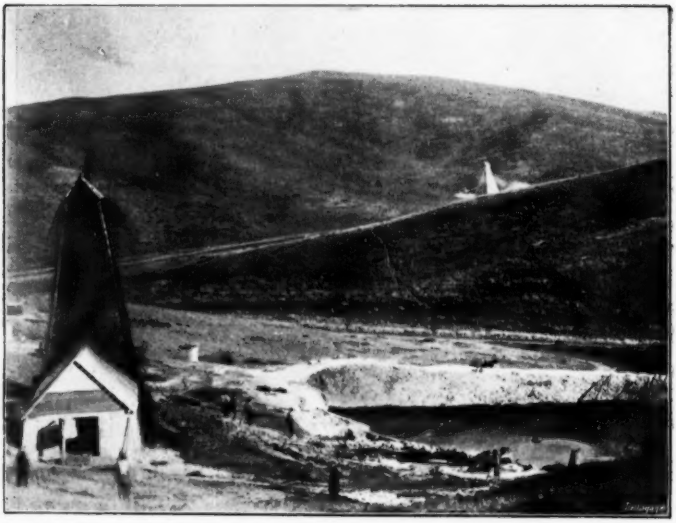
The winning of the oil was now to be investigated, and we were fortunate in being able to see all stages of progress, which at once showed us that Bili-Eibat was by no means an unpromising field. The boring derricks are of the usual kind, but are entirely covered in, and the building in which the engine is placed is continuous with the derrick. The boring is done with iron rods and a free-falling bit, the appliances being of the usual description, and we had the opportunity of witnessing the starting of a boring, the lining of a boring, the widening of a boring, the deepening of a boring, the lengthening of the rods, the changing of the bits, and even the recovery of a lost bit; and, I must say, the operations were conducted with expedition and much skill. In one case the casing tubes in the upper part of the well were 26 inches in diameter, were made of plates riveted from inside, and were to be continued to a depth of 200 feet. The ultimate boring was to be 1,400 feet, and would cost about £20 a fathom. In course of our progress, a spouting well was visited. It presented a striking and beautiful sight. The bright sunlight coming through the open door caught the ascending column, and made it shimmer and glitter in a dazzling manner, while the falling streams, drops, and spray glistened like so many rich-coloured gems. Then the whole was surrounded by a curious prismatic halo. This fountain came from a depth of 1,418 feet, and was giving 192 to 208 tons a day after 16 months' spouting. The oil from the wells flows away into open tanks made by digging out and tanking up the soil. A fountain produces more oil than can be dealt with, and much is lost by flowing away, and much by sinkage, although the tanks soon acquire an impervious coating of slime, and so retain the oil that flows into them. Another loss is by evaporation; this is sometimes so great, owing to long exposure in the case of fountain produce, that the oil ultimately is fit only for fuel oil, or masut, as this untreated oil is called. This is especially the case with Bili-Eibat oil, which is deficient in viscosity.

In most of the wells oil was being pumped, or, rather, wound,



BORING AN OIL WELL IN THE BAKU DISTRICT.

up, for the large proportion of sand that accompanies the Baku petroleum prevents the use of a pump. Therefore, the oil is drawn up in great buckets,—that is, in cylinders of a diameter suitable to the diameter of the well, and of any convenient length, fitted with a valve opening upwards in the bottom. This is run down into the oil, allowed to fill, and drawn up; then the oil is let out into a trough leading to the tank outside, and the operation repeated. The time occupied depends on the engine and depth of the well, and the quantity drawn each time depends on the capacity of the cylinder and the completeness



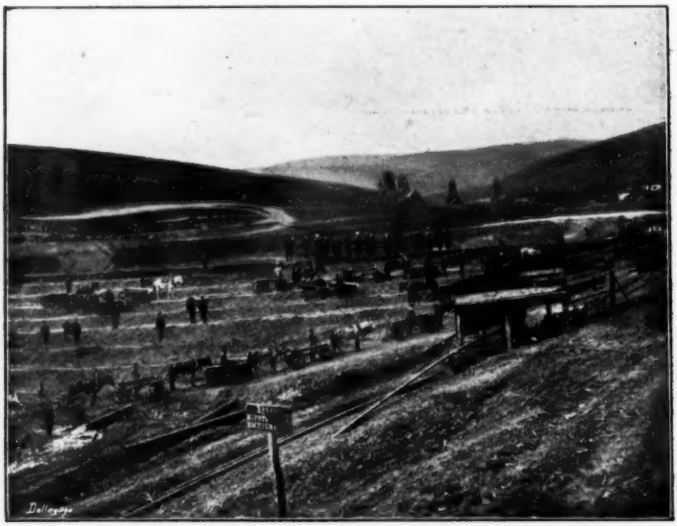
AN OPEN TANK, OR RESERVOIR, FOR OIL.

of the displacement of the air. Two minutes seemed a fair allowance of time from surface to surface, while the quantity drawn seemed to vary from 12 tons a day upwards. When there is water in the well, a cylinder of water is drawn periodically for this purpose. The cylinder is run to the bottom of the well, the valve opens, and the water displaces any oil that has entered the cylinder during the descent, the valve closing again when the cylinder is lifted. Recently Bili-Eibat has produced as much as 1,120,000 tons a year, of which 75 per cent., or 540,000 tons, came from fountains. The maximum yield in the year from any single fountain well was 392,000 tons from a depth of 1,358 feet. Bili-Eibat has more fountains than any of the other fields, and the average yield per well, about 32,000 tons, is higher. Moreover, it shows an increase, whereas the other fields show a decrease. The greatest average comes from wells from 1,260 to 1,330 feet deep. At the end of 1896 there were at Bili-Eibat 25 productive wells and 26 new borings; 2 wells were being deepened, and 1 was being repaired, and there were 4 new derricks and 15 unproductive wells. Of the Bili-Eibat oils part is refined on the spot, part is shipped to Black and White Cities, part is taken overland to Persia, and part by the Caspian sea and the Volga to the interior of Russia.

The next visit was to the north east of Baku, to the three great

LATOUROFFS NO. 19 WELL AT BALAKHANY.

oil-fields of Balakhany, Sabountchi, and Romany. They form respectively the western, central, and eastern parts of an almost triangular area of land measuring about 4½ square miles and representing the most productive oil area; but, inasmuch as the country for a con-



BUILDING THE DAM OF AN OIL RESERVOIR.

siderable distance outside this area is above the sea, conditions for studying the geology are excellent. Moreover, the great number of borings facilitate immensely the progress of this study. The result of this is a demonstration that the deposits are exactly similar to those already referred to at Bili-Eibat; moreover, they also form an anticlinal with the axis, inclining slightly from north-west to north-east and with gently sloping flanks. The oil-bearing beds, where they extend beyond the rich area, consequently sink deeper and deeper under the overlying Aralo-Caspian limestone, on the northern, eastern, and southern sides, in the rich area itself travelling from east to west. The overlying clays, the oil-bearing strata, and the underlying clays and eocene beds full of fish-remains come to the surface in succession; thus the oil-bearing strata are thrust out at the western side by non-productive beds, whereas on the eastern side the oil-bearing strata do not terminate, but simply get deeper. Evidence of this is afforded by an inspection of the Sourakhany district, where gas escapes in vast quantities from every fissure in the limestone. This, too, has been going on for centuries, as is testified by a very interesting and striking ancient temple of the fire-worshippers, where the natural gas maintained their perpetual fires. It was a source of regret to most of us to observe that

A BURNING WELL.

this remarkable relic of the past has not been treated with the respect it deserves, for in immediate proximity to it there has been erected a hideous refinery; one sighed for very much less refinery and a little more refinement. In this neighbourhood, too, the limestone is still burned to lime by simply heating it up, piling it over a fissure, and igniting the gas. When the burning is complete, the fire is smothered with earth, and the lime cleared away, and the operations are re-started on a new lot of broken limestone. But, returning westward, it is noteworthy that the character of the oil below the gas varies with

the strata in which it is found, being lightest in the uppermost and heaviest in the lowest. For instance, in the overlying clay oils of a specific gravity from 0.820 to 0.840 are found; the oils in the naptha-bearing beds have a specific gravity of 0.865 to 0.875; while the underlying clays yield oils of a specific gravity of 0.885 to 0.920. Taking into consideration the deposits lower still, full of fish remains, we find some support of considerations recently set forth by the writer.

The operations at these oil-fields are conducted in a manner similar to that followed at Bili-Eibat. That is, a covered derrick is erected; the boring is wide at the start and cased with wide tubing; as it descends, it narrows, and the oil is allowed to flow, or to spout, or to be pumped, and then collected in open tanks dug in the ground. It was here, on the property of the European Petroleum Company, that we saw an intermittent fountain. It was an absorbing spectacle to watch the pumping steadily progressing through the open door of the derrick, and then suddenly to see the bucket, on arriving at the surface, followed by a dark column suggestive of the rod of a hydraulic lift, which, however, almost instantaneously outran the pump and rose out of sight into the closed upper part of the derrick, to reappear immediately, partly as a cloud of spray projected from the top of the derrick to fall in a shower of chatoyant drops, partly as a glittering cascade formed by the oil pouring over the top and oozing out between the covering planks and rushing down outside the derrick, unmercifully drenching the men below and covering the ground for a distance round with sand and streams of oil. This performance was repeated two or three times an hour, and the well was yielding 640 to 800 tons a day from a depth of 1,195 feet.

The following data furnished by Mr. Leon, with the permission of the European Petroleum Company, show the working of these fields during 1896:

	Productive wells.	New Borings.	Deepenings.	In Repair.	New Derricks.
Balakhany	242	58	13	18	31
Sabountchy	246	78	22	39	20
Romany	69	26	7	10	15

	Non-productive wells.	Average produce per well. tons.	OUTPUT.		Percentage of total by fountain.
			Pumped. tons.	Fountain. tons.	
Balakhany	55	4,725	1,368,000	2,363	0.1
Sabountchy	91	5,920	2,217,600	225,872	9.1
Romany	9	14,880	918,400	330,464	26.1

In the Baku district borings have to go deeper and deeper; that is, the upper oil-bearing strata are becoming exhausted. The deepest well is about 1,750 feet. The largest average yield in Balakhany is 5,760 tons from a depth of 700 to 770 feet; in Sabountchy, 10,320 tons, from a depth of 980 to 1,050 feet; in Romany 22,624 tons, from a depth of 1,050 to 1,120 feet. The geological character of the ground accounts for these increases in depth, or, *vice versa*, the increase in depth has suggested the geological views entertained. Moreover, as the wells get more distant from the centre of the field, the water-bearing upper beds are encountered in the borings, and introduce an undesirable element, which, however, does not impede progress to a very great extent, as may be gathered from the following data, obtained at the time of my visit to Baku.

GENERAL STATISTICS OF THE BAKU PETROLEUM MINES.

	1890.	1891.	1892.	1893.	1894.	1895.	1896.	First 7 months of 1897.
Millions of tons of petroleum produced	$3\frac{2}{3}$	$4\frac{2}{3}$	$4\frac{2}{3}$	$5\frac{1}{3}$	$4\frac{3}{4}$	6	$6\frac{1}{3}$	4
Thousands of feet bored.	$103\frac{2}{3}$	140	$81\frac{7}{10}$	77	90	146	197	147

POSITION OF THE PETROLEUM MINES ON THE 1ST OF AUGUST, 1897.

Number of completed wells			917
of which there were (a) Productive		644	
(b) Deepening		46	
(c) In repair		47	
(d) Being cleaned		5	
(e) Idle		175	917
Wells in boring			295
Wells sunk since systematic working of the petroleum fields at Baku			1,650
Area of petroleum fields in work, square miles			2.172
Number of firms engaged in the petroleum operations			97

It is strange to look back ten years and recall the rumours then in circulation that the Baku oil district was exhausted. It required the pen of the famous chemist, Professor Mendeleeff, to refute the statement. It has been my intention to set forth actual facts gathered, and impressions formed, during a recent personal inspection of the district, and to show how little changed, otherwise than in magnitude, the character and position of the Baku petroleum industry are, even after many years. It remains to add that we enjoyed unbounded hospitality during our stay in Baku, and that the European Petroleum Company not alone photographed us and presented us with copies of the photograph, but also kindly furnished data and illustrations.

EFFECTIVE SYSTEMS OF FINDING AND KEEPING SHOP COSTS.

By Henry Roland.

THE SPRAGUE ELECTRIC COMPANY'S METHODS.

TIME passes, and it works changes as it goes. Ten or eleven years ago Mr. Frank J. Sprague was fighting the battle of electric traction almost single-handed against the combined negative of all engineering authorities.

Time has passed since then, and has worked its changes. To-day one of the largest divisions of railway service has been delivered over to electric traction so completely that it stands as unquestioned practice. By another of time's changes electric street-railway traction, as exhibited in the trolley car, is no longer a matter of absorbing personal interest to Mr. Sprague, although some of his patented inventions still hold exclusive fields in street-car-motor construction. Vertical translation by electricity in the various forms shown by the Sprague elevator, electric motors, dynamos, fans, and conduit work are some of the constructions of the Sprague Electric Company, with offices at 20–22 Broad street, New York, and factories at Watsessing, New Jersey, and 527 W. 34th St., New York City.

Mr. Edward H. Johnson, Vice President and General Manager, is the chief executive officer, and to him is due the remarkably effective organization of service now in force. A distinguishing feature of this organization is the perfectly clear definition of the duties of each officer and employee, by which individual responsibilities are fixed beyond doubt or question. This highly important requisite of successful operation is due entirely to methods and allotments, many of them displaying the highest ingenuity and greatest discrimination, originated by Mr. Johnson.

The present Sprague Company is the legal successor of the Sprague Electric Elevator Company and the Interior Conduit and Insulation Company. It is capitalized at $5,000,000, and employs more than a thousand men.

The Watsessing factory is among the finest American industrial structures, and its equipment is the best that American machine-tool makers can furnish.

Until recently the system of cost-keeping used at the Watsessing factory was perhaps the least satisfactory of its features, though possibly better than the systems used in many concerns of high repute. It was resolved to replace it with the best system that could be devised. This replacement has been effected, and the Sprague Company has

most courteously afforded me every facility for the preparation of a concise and detailed description of its more prominent labor-saving and accuracy-securing devices, many of them entirely new and of the highest interest to all factory managers and accountants. It will be presented in two papers, of which this, the first, will be devoted to flat-cost-finding and keeping, while the second, based upon the Sprague practice, will deal with the expense account, expense apportionment, and estimating.

The system of factory accounting now used by the Sprague Electric Company was installed by Mr. J. N. Gunn, of Boston, within the past year, and is comprehensive, including an absolutely complete record of all factory expenditure and performance, while at the same time it is cheap, entailing far less clerical labor than some systems which do not approach the Sprague results in completeness of detail.

This highly-desirable outcome is obtained, first, from a thorough comprehension of the broad problems of factory accounting, of course, but none the less from novel and, in many instances, highly-ingenious combinations which are neither more or less than original inventions, and which must be thought out in detail for each individual factory. No two manufactures are precisely similar, and, while the general scheme of accurate factory-accounting is unvarying, novel combinations and modifications can and must be made in each case, to bring the actual working details of the cost-keeping system into harmony with the inherent peculiarities of the individual concern. In other words, it is impossible to produce a cost-keeping system which shall be the very best for every factory.

This proposition should be fully comprehended. Many manufacturers who are aware that their own cost-keeping does not produce satisfactory results believe that there is such a thing as a universally-applicable system of factory accounting.

It is true that a system of factory accounts can easily be devised which will, if carried out in all its wearisome and costly multiplicity of detail, give a complete record of the performance of any factory as a whole and in detail; and it is these burdensome and practically impossible systems of universal application which are presented in the ponderous treatises on cost-keeping produced by accountants who were accountants simply and solely, and hence saw no impropriety in applying successful weaving-shed and spinning-room methods alike to the foundry, the machine shop, and the factory producing small metal wares, without any change of detail.

Not only are these universal systems cumbersome and costly, but they fail utterly to give directly those comparable totals that indicate changes conducive to shop economies; and it may be asserted, with-

out fear of contradiction, that the first requisite of an ideal cost-keeping system is that it shall force the instant recognition of cost-fluctuations, and the constant comparison of related cost-factors.

Accepting this, it becomes immediately evident that the best cost-keeping system for any one concern must be especially devised, and fitted to the particular manufacture carried on, and to the special conditions of trade environment under which the individual factory is doing business; and that there cannot possibly be even a fairly good approach to the best results without specially-devised details exactly suited to the case in hand.

It is the purpose in these articles to avoid bald assertions, and to present intelligible records of actual practice; but, believing that there is a common impression that a generally-applicable and altogether perfect cost-keeping system pursues its hidden and inevitably wealth-producing existence within the mahogany and plate-glass labyrinths of the offices of some of our great factories, it seems proper to assert that there is no such possibility. In point of fact, very few large establishments are satisfied with their factory-accounting systems, and many of these systems are highly-tedious and burdensome complications, non-homogeneous, without a central and dominating motive,—actually mere aggregations of makeshifts instead of wisely-devised unities.

The cost-keeping system which Mr. Gunn has introduced at the Sprague Electric Company's factory records everything on cards adapted to card index filing, and hence calls for no books or book-keeping whatever. The nearest approach to an account-book in the factory-cost-keeping proper is produced by filing some of the larger blanks in the "Tengwall" file and binder, made in all needful sizes, and holding from one to two thousand sheets securely in book form, any sheet being instantly removable without disturbing any other sheet. This use of cards, card system filing, and the Tengwall binder, saves the labor of transcription. All additions are made mechanically on a "Felt and Tarrant Comptometer,"—computing machine,—and by these aids the labor and opportunity of error are vastly reduced.

Too much cannot be said in favor of the "card system," as opposed to bound account-books of the ordinary form. There is no space here for enlargement on this important topic. It must suffice to say that all cost accounts can be kept by means of the card system in much more accessible form, and with vastly less labor, than by the use of bound volumes. Both index cards and boxes should be purchased of regular manufacturers, as their production requires great experience and costly special machinery to give satisfaction.

The business offices of the Sprague Electric Company are in the

INSTALLATION			GENERAL ORDER No. B
Elevator No.	Draughting Room No.	Contract No.	Date 189

Ship to
Via
Bill to
Please deliver the following on or before

Shipping Check	Date Shipped	Date Billed

Quantity	DESCRIPTION	Shipped	How	Number	Charge	Price

THE SPRAGUE ELECTRIC CO., WATSESSING, N. J.

FIG. A. OFFICE ORDER TO FACTORY; MANIFOLDED 5-FOLD.

Commercial Cable Building, New-York, and include the engineering department, where all work is designed, and the construction department, which installs the products of the factory. In addition, the New York office has charge of advertising, sales, travellers, and agents, and makes all orders to the factory.

The factory has a general manager, who exercises entire control. It is divided broadly into the production department—sub-divided into drawing room, pattern-shop and machine shop, electrical department, and so on—and the accounting department, where all the factory accounts are made up,—twenty-three departments in all. The factory does nothing except on order of the New York office or the general factory manager.

Factory orders are manifolded five-fold. Two copies are filed in the New York office, in the filing room, which is in charge of a chief and two assistants, whose sole duty is to file and keep all papers of every description relating to the business of the house, the system adopted being such that any paper required can be instantly produced or traced, as any document once delivered to the filing room is thenceforth receipted for, if removed. One copy of each work order is filed under consecutive number, and the other is filed in the individual customer's file-box. This makes it possible to instantly find the order either by its number or by the customer's name.

Production order No.	To Foreman	Date 189

Please execute the following order and charge all labor and material to the above order number.

SPRAGUE ELECTRIC CO. (Factory System Form Or 1) General Factory Manager

FIG B. PRODUCTION ORDER; THICK AND THIN.

The production order is printed on one side only, in the form shown. It is $7\frac{13}{16}$ inches wide and $9\frac{13}{16}$ inches high.

Three of the five "manifolded" work orders go to the factory. Of these, one is delivered to the general manager, as head of the production department, one to the head cost-keeper, and one to the shipping clerk. If detail drawings are needed, they are ordered from the drawing room by the general manager. The chief cost clerk files his copy of the order in a Tengwall binder, where it is kept during the process of production. The general manager's order, after approval, goes to the "tracer," whose duty is to fix the date of shipment, which must be rigidly observed. The Tracer keeps his production orders in a filing box while current, and returns them to the accounting department when filled. The shipping clerk, on shipment of an order,

Sub. Prod. order No.	To Foreman	Date 189

Please execute the following order and charge all labor and material to the above order number.

SPRAGUE ELECTRIC CO. (Factory System Form Or 2) Foreman

FIG. C. SUB-PRODUCTION ORDER, THICK AND THIN.

makes triplicate manifolded shipping lists, one going to the New York office and one to the customer, while the third goes with the original order to the accounting department.

The "Tracer" is the unusual feature of this procedure, his work being done in other concerns by the Shipping Clerk or Shipping office. It will be observed also that the drawing room is relieved of all responsibility, except for drawings, as it has nothing to do with ordering either work or material into the shop.

Instead of signatures, or individual name or symbol stamps, those in responsible position use conductor's punches, each cutting a differently-shaped hole in the certified document, whatever it may be. This signature is always punched in the little enclosed square. The punch system has many advantages over the written or printed name or symbol. Many of the cards are printed in duplicate, both bearing the same number,—one on thick paper and the other on thin.

The factory manager may hold an office order at his discretion. When an order is accepted by the factory, the general manager issues "production orders" to the foremen of the proper departments, these production orders being manifold duplicates on thick and thin paper, gummed together at the left-hand narrow edge, so as to be readily separated after manifolding, and numbered consecutively in duplicate, as shown in Figure B. The size of this card is $3\frac{5}{16}$ by $4\frac{7}{8}$ inches.

The thin production order goes to the department foreman, and the thick one goes to the accounting department, where it is filed in a card system file while current, and when stamped "order completed" with date, is placed on permanent file, in a long index box.

In addition to the principal production order issued by the general manager only, sub-production orders may be issued by any holder of a principal production order. This reduces the manager's clerical work to the mere filling of the principal order, and enables the foreman addressed to obtain materials or labor from any other department, as he may require, in executing the principal order. The sub-production order, tinted robin's-egg blue, is shown in Figure C; it is in duplicate, size $4\frac{7}{8}$ inches by $3\frac{5}{16}$ inches. The thin card is held by the foreman addressed, and returned, stamped "order complete," to the accounting department. The thick sub-production order goes directly to the accounting department, and is filed with the principal order.

All stock and materials bought are ordered by the assistant purchasing agent from the "Foreman's Material Requisition," Fig. D, size $3\frac{5}{16} \times 5\frac{5}{16}$, on the purchasing order, Fig. E, size $7\frac{7}{8}$ by $4\frac{5}{16}$ inches, a manifold duplicate being sent to the purchasing agent in New York. The receiving clerk, who receives all material, has no

On Order No.	Department	Foreman ☐	Date 189
Quantity	Article		

PUT ONLY ONE ENTRY ON A CARD. MAKE ALL MEMO. ON THE BACK.

SPRAGUE ELECTRIC CO., Foreman's Material Requisition. Fac. Syst. F. M 2.

FIG. D. FOREMAN'S MATERIAL REQUISITION.
Made either on Rough Stores Keeper or Purchasing Agent.

notice of this order, and is therefore forced to make an original examination and report of every consignment of material received, on the "Materials Received" cards, Fig. F, size $5\frac{1}{16}$ by 4 inches, which go at once to the accounting department, and are checked with the invoice.

Fig. G shows the "Materials Returned" blank, size $4\frac{7}{8}$ by $3\frac{5}{16}$ inches, salmon tint, thin paper. This card is used for everything which comes into the shop, except new material. All material returned is immediately inspected, and its value credited to the proper account. It is punched by the foreman who receives the article.

Except rough castings, which are delivered on the shop floor, all

Order No..... SPRAGUE ELECTRIC CO., Bloomfield, N J.
To .....
Please send us the following goods to .....
Telegraph Address: Newark, N. J.
Send bills in duplicate. Terms 60 days. Via .....

DUPLICATE.

Required by .....
For Order No..... SPRAGUE ELECTRIC CO.
..... Purchasing Agent.

Important. In referring to this order use number and put same on your bill—this will facilitate payment.

FIG. E. PURCHASING ORDER; ISSUED BY PURCHASING AGENT ONLY.

Required For	Department	Foreman	Date 189
Quantity	Articles		
On Purc. Agt. Order	Remarks		
Received by			

PUT ONLY ONE ENTRY ON A CARD AND RETURN PROMPTLY TO OFFICE

SPRAGUE ELECTRIC CO. Material Received Card Factory System, Form M 1.

FIG. F. MATERIALS RECEIVED CARD.

new materials received go to the rough-stores room, under charge of a stores keeper, who keeps the stock up, and three assistants. Stock is checked out of the rough stores room on sub-production orders, which are immediately transmitted to the accounting department. All of these cards are placed in their appropriate files as soon as inspected by the chief accountant. They are brought in from the works by messengers, and there is no accumulation of them, as there would be if transcription were practised.

Fig. H shows the "Individual Factory Cost Record" made by the factory to the New York office; size, 4⅞ by 3$\frac{5}{16}$ inches; filed in New York Office, and available in estimating.

On Order No.	Department	Foreman	Date 189
Quantity	Article		

PUT ONLY ONE ENTRY ON A CARD. MAKE ALL MEMO. ON THE BACK.

SPRAGUE ELECTRIC CO. Foreman's Report Material Ret'd. Fac. Syst., Form M 3.

FIG. G. MATERIALS RETURNED.

Date of Order	Date of Completion	Class Symbol	Production Order No.

Quantity	Description of Work Done

Estimate								
Date	Material	Value		Date	Labor	Hours	Value	
	Total Material				Total Labor			
	Add %				Shop Exp. @			
					Aggregate			

COST SHEET SPRAGUE ELECTRIC CO.

FIG. H. INDIVIDUAL FACTORY COST RECORD.

Fig. I shows the "Comparative Cost Card," giving successive costs of same article under the shop name, and indexed alphabetically. Size, $3\frac{7}{8}$ by $3\frac{15}{16}$ inches. These cards show at a glance whether the flat cost of any factory product is stationary, rising, or falling. This record is duplicated at the New York office and is used for estimrting.

Each machine tool and each workman has an individual record in the accounting room.

Figs. K and K 1 show the front and back of the Individual Machine-Tool record. The front of the card gives particulars of purchase and durability; the back gives particulars of repairs and present condition of effectiveness. This card is obviously of the greatest

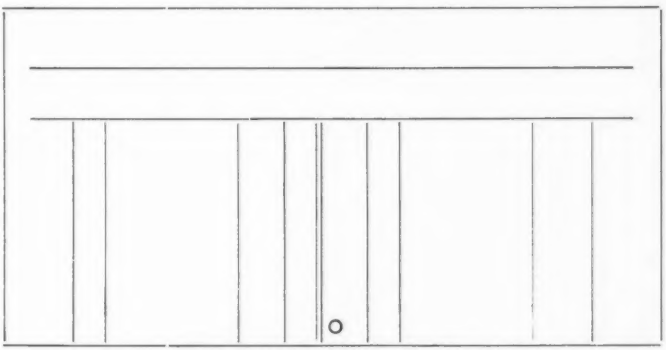


FIG. I. COMPARATIVE COST CARD.

value in determining subsequent factory equipment purchases. The back is filled in from the "Repair Cards," which are used both for shop repairs and for alterations or improvements in a previously-completed shop production.

Figs. L and L 1 show the front and back of the "Repair" order. This card issues only from the general manager.

Suggestions for repair or betterment are in order from any source —workman or foreman. These cards are thick and thin, in duplicate consecutive numbers, the thick one going direct to the accounting department, and the thin one being held by the foreman who executes the order, until sent to accounting department with the "order filled" stamp and foreman's punch, the total being charged to the "Plant and Betterment Account," credited in part to assets.

Rough castings are delivered directly to that part of the machine-shop floor most convenient to the machine tools by which they are to be finished. There are always exactly enough to fill the order, and no more. The receiving clerk's card goes immediately to the account-

No.	Name of Tool	
Description		Price
Maker	Bought from	Date Bought
Date / Set	Location	Rate of Depreciation.
Transferred		

FIG. K. INDIVIDUAL MACHINE RECORD; FACE.

ing department. In case of shortage or breakage a "waster" report is made instantly to the foreman, who takes the needful steps for replacement, the accounting department being, of necessity, notified at once. Material is issued from the rough stores by the rough stores keeper on the presentation of the foreman's "Requisition Card," Fig. D; size, $5\frac{1}{16}$ by $3\frac{1}{16}$ inches. The rough-stores keeper sends these orders to the accounting department, stamped "Order filled."

It will be observed that in all this ordering of internal shop trans-

Order No.	For Dept.	Date

To

Please execute the following order and charge all material and labor to the above order number:—

Plant and Betterment Order. Factory System Form 01 3.

FIG. L. REPAIR ORDER; FACE.

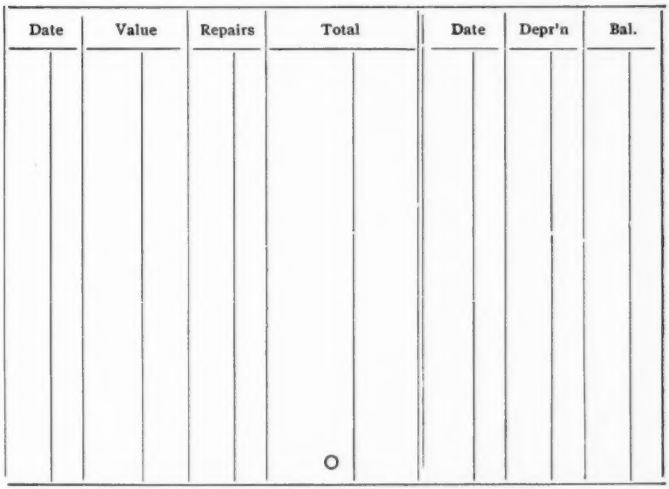


FIG. K1. INDIVIDUAL MACHINE RECORD; BACK.

actions, the orders are made on cards which serve the several purposes of order, receipt, and final accounting department record, without transcription, and with the least possible labor, and that the accounting department has instant notice of every transaction, so that, within a short time after the completion of any of these shop sub-production transactions, the report has been vised by the chief accountant and "posted,"—that is, filed away in its proper place, instantly accessible when required and adjacent to its kindred records.

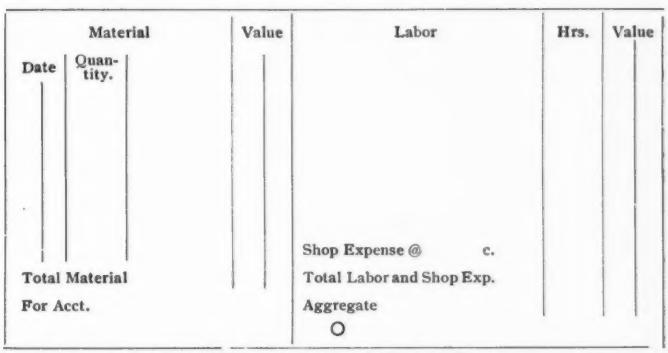


FIG. L. REPAIR ORDER; BACK.

Workman's Name	No.	Date 189
Operation or Work		Foreman's Approval.

The rate given below has been agreed upon between the workman above named and the Sprague Electric Co , and will be retained until further notice.

Rate	Per	For what order or part
$		

O

SPRAGUE ELECTRIC CO. Piece Rate Agreement.

FIG. M. PIECE RATE CONTRACT.

Delays are dangerous, and nowhere more so than in matters of the counting-room. Records made by transcription are uncertain. Checking from one man's record to another is tedious, costly, and not infallible. All of these sources of errors are eliminated by the use of the index card, in manifold duplicate where the workman must hold a copy, so that every current item of indebtedness may be said to be actually posted in the final books of the accounting department, at the instant the indebtedness is created. Nothing is allowed to remain for a moment on the chief accountant's table, where all cards are delivered. The cards are placed at once where they belong, and the original accounting-room record is finished and done with, placed in its proper sequence, and indexed, instantly accessible forever, within a very short time after the account item is created. The value of promptness in business transactions cannot be overestimated, and Mr. Gunn's methods insure a promptness never before made possible in machine-shop cost-keeping.

The introduction of that unknown variable, the human element, of course brings trouble.

About 30 per cent. of the Sprague Factory workmen are on piece-rate. The remaining 70 per cent. are on day rates. The average hour-rate of the factory is very high, being about 25 cents, with a considerable number of young hands in the winding and kindred de-

Name	J. JONES.										No. 261
Period	Date End'g		At Day Rate		At Pc. Rate		Hr. Av. Pc.	Gain		Loss	
1 Week	3	16	12	50	14	75	20	2	25		
1 Week	4	20	14	50	20	00	2.30	5	50		
Comparison of Earnings							O				

FIG. N. WORKMAN'S COMPARATIVE PIECE-RATE EARNINGS.
(Fill as filled.)

partments. A great portion of the work, however, demands excellent machinists, which accounts for the high average.

The piece-prices are based on an assumed individual workman's day-rate, which he may exceed by 25 per cent. before incurring the liability of "rate revision." Considerable latitude is given in the case of specialized laborers, low-rate men who have become experts in some single production; and a piece-worker rated at $2 per day, for instance, may go up to $20 per week at piece-rates, before his reprehensible overproduction and product-cheapening is met by the penalty of a rate-reduction.

The piece-rate contract is made in manifold, on thin and thick

Name			No.
Residence			Age
No.			
Date employed	Department or Operation	Rate per day	
Date transferred			
Date Emp. Ceased	Cause		
	Left-Discharged-Suspended		
	O		

FIG. O. WORKMAN'S PERSONAL RECORD.

Man No.	Department Foreman's Approval	Date
Name		
	Straight Time	
	Over Time	
	Extra over Time	
Charge to Order No.	Hours	Value
Charge to Order No.	Hours	Value

FIG. P. WORKMAN'S DAILY TIME CARD.

cards Fig. M, the workman holding the thin card, and the thick card going on file in the accounting department. The size is $4\frac{1}{16}$ by $2\frac{1}{16}$ inches.

The pale yellow card, shown in Fig. N, gives warning when a piece-rate workman is becoming too diligent and too expert, earning too big a weekly wage. As long as his pay stands steadily at about his permitted 25 per cent. advance over his assumed day-rate, the piece-rate is not disturbed; but, when Mr. J. Jones has the temerity to reach a gain of $5.50 in one week over his assumed day-rate, things must be seen to, promptly.

A third card relating to the workman solely is shown in Fig. O, called the "Workman's Personal Record." The size of this card is $4\frac{1}{16}$ by $2\frac{1}{16}$ inches, and it is filed in alphabetical order. The blank headings sufficiently indicate its character and uses.

The experience of the Sprague Company is against mechanical time-recorders. Men could not pass the one they now have, which is out of commission, fast enough. There are no gates, and no closed doors, and no watchmen. Each workman, on leaving the works at night, is given two similarly-numbered brass checks, marked A. M.

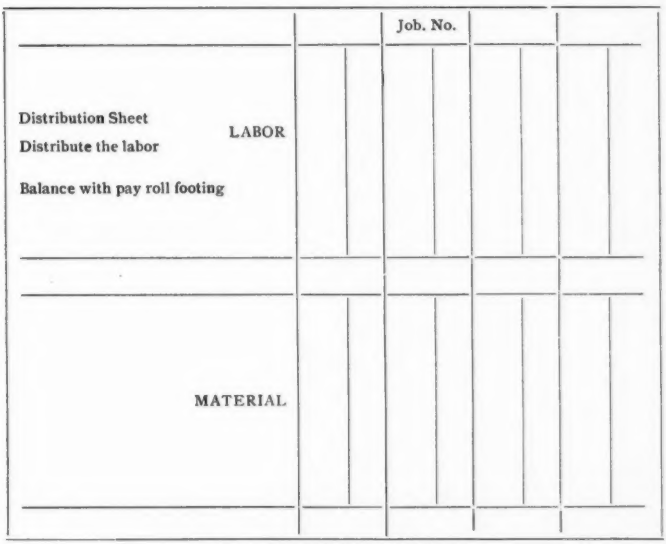


FIG. Q. DISTRIBUTION SHEET.

and P. M. ; these checks are delivered by a check clerk from a check-board, where they hang in sequence, accessible only to the check clerk. There are four check-receiving boxes in four different locations in the shop, under charge of check clerks. These boxes have three slots, "Full Time," "Half-hour late," and "Miscellaneous." The slide over the full-time compartment is closed at the sound of the whistle, and the half-hour late slot is opened. The third slot is for the use of the check-box keeper only, who deposits therein what he pleases. Time is paid from the check box record ; no check, no pay. If a hand leaves the shop without his checks, he cannot obtain them again without a satisfactory explanation.

The workman's daily time-card, shown in Fig. P, has perforated stubs for four separate jobs, and a column for his daily total earning. The size of this card is 5 inches by 7 inches, and the four separate charge slips are each one inch wide from one line of perforations to the next, leaving the permanent top card, containing the totals from which the pay roll is made up, 3 inches wide.

The separate order charges are torn off at the perforations, and are sorted to order-numbers, and the total of time charged to any one order is then aggregated twice a week on the computing machine, and this total is entered semi-weekly on the "Distribution

Article		Prod. Order
		Date order completed
		Actual cost
		Estimate
		Factory expense rate

Cost of one only	Material	Dir. Labor	Factory Exp.	Total
TO COST DEPARTMENT.	SPRAGUE ELECTRIC CO.			

FIG. R. SUMMARY OF SINGLE PIECE COSTS.
Sent to cost estimating department, New York.

Sheet," shown in part in Fig. Q. This sheet may be of any size. That used is 10 inches by 24½ inches, punched at the left-hand end to go into the Tengwall binder, and ruled into four divisions by horizontal double lines, and filled with vertical dollars and cents columns, ⅝ of an inch wide. The Sprague Distribution Sheet has spaces sufficient to charge each of 68 different orders with 12 separate semi-weekly labor charges and 12 separate weekly material charges, with space for totals at the foot of each vertical column. The top line and middle line are for order numbers, and the top horizontal division is for semi-weekly labor charges; the next division is for weekly material charges, with the same order of numbers. The two lower divisions serve the same purpose for orders whose numbers appear in the middle line. The horizontal divisions are filled with semi-weekly totals, and the aggregate of the labor totals balances with the pay roll.

Fig. R shows the form of the cost summary card, size $5\frac{15}{16} \times 3\frac{15}{16}$ inches, giving the total factory cost of a single article, great or small. The totals are made up from the Cost Record, Fig. H. This card goes on file in the estimating department.

REVIEW OF THE ENGINEERING PRESS

A Year's Progress in Engineering.

AT the recent convention of the American Society of Civil Engineers, the president, Mr. Alphonse Fteley, delivered as his annual address a comprehensive review of engineering progress during the past year. Although it is impossible, within the limited space here available, to give even a close abstract of this excellent account of a year's progress in civil engineering, some points of Mr. Fteley's address may at least be noted.

Railway construction and operation are passed over lightly, the recovery from the set-back of 1893 not having been sufficiently marked to render this branch of engineering noteworthy; but the phenomenal development of electric railways continues. The advent of the trolley car has revolutionized travel, and affected the movement of population in the neighborhood of large centres.

The most important questions in connection with canal construction are those of a connection between the Great Lakes and the Atlantic, and of a waterway through the isthmus. The former is under investigation by a United States commission, and the latter has been revived as a consequence of the war between Spain and the United States. Both the Nicaragua and the Panama schemes are under investigation, the former by an American and the latter by a French commission, and from present indications it appears that the government of the United States may undertake the work as a national project.

In bridge construction the development of large spans has proceeded. The United States government has required the building of bridges up to 1,000 feet span over the Ohio, Mississippi, and other rivers. The necessities of traffic in New York city have given renewed impetus to the designing of suspension bridges of unprecedented span, and have caused the introduction of novel details, made practicable by recent improvements in the manufacture of steel.

The recent reconstruction of the bridges at Niagara has shown the possibilities of steel arch construction, and the various designs for a suspension bridge over the Hudson river have carried the possibilities of bridge-building much beyond long-accepted limits. In this connection also must be noted the tendency to return to the construction of stone arch bridges, wherever local conditions as to cost of foundation and length of span have justified the generally larger outlay necessitated by this class of more permanent structures.

The modern tall building, with its steel skeleton structure, and deep foundations, has continued to find favor. Many new problems as to the stability and fire-resisting properties of such buildings have presented themselves, but the complicated questions of their equipment, including untried methods of carrying passengers and of supplying water, sewerage, heating, ventilation, etc., appear to have been solved satisfactorily.

In connection with water-supply are to be noted the following points: the extravagant consumption, or, rather, waste, appears to increase as increased provision is made to meet it, and, unless some more rational method than that now in use be employed to regulate consumption, it will be impossible to make reasonable provision to meet it. With the increased demand for water come also further requirements as to its purity. Filtration processes have been installed, and their action studied, and much valuable information has been gathered. Radical chemical and biological changes have been found to take place in the operation of filtering, and bacterial life has been recognized as the most potent instrument for the conversion of organic matters into mineral compounds.

Sanitary engineering is so closely allied

to water-supply that it should be considered in almost the same connection. The necessity for the final discharge of sewage into streams which may subsequently be used for water-supply renders the application of means for rendering the sewage innocuous a necessity. Sewage irrig tion, filtration, and chemical precipitation have all been applied, both in the United States and in Europe, and much progress has recently been made in this important branch of engineering science.

In many branches of engineering valuable researches have been made, among which may be noted the experiments of the Massachusetts State Board of Health, which have contributed so much to the development of sanitary science; also the systematization of the tests of materials under the auspices of the International Association for testing materials; while the work of the forestry division of the United States department of agriculture has contributed greatly to our knowledge of timber physics.

In all this and much other work the professional standing of the engineer has been advanced, and his position as an eminent member of the community emphasized. The comparative youth of the enineering profession as compared with the professions commonly called learned has often caused it to be passed over by those who have failed to appreciate the importance of its work. With the increasing prominence of engineering work in everyday life, however, the standing of the engineer is becoming more fully recognized, and a continual gain in this respect is evident.

Portland Cement.

ALTHOUGH Portland cement is a very well-known trade article, there has probably nowhere been given so exhaustive an historical and technical description of its manufacture in various parts of the world as is contained in a paper read before the Civil Engineers' Club of Cleveland by Mr. Bernard L. Green, and published in the *Journal of the Association of Engineering Societies*.

After noticing the discovery of the principle involved in the use of hydraulic cements by Smeaton, in connection with the construction of the Eddystone Lighthouse, the patent of Aspdin, and the arbitrary selection by him of the name "Portland," are referred to, the name having been selected on account of the resemblance in point of color and texture to the oölitic limestone of the island of Portland, well-known and in great favor as a building stone.

"Portland cement is produced from the intimate mixture of lime and clay, burned to a point just short of vitrification, and ground to a fine powder. It is thus essentially an artificial product and clearly distinguishable from the natural cements. It can be made from any materials having the necessary ingredients in the proper proportions, and these proportions may vary between narrow limits, depending somewhat upon the method of manufacture.

"Scientists have now proved almost conclusively just what chemical combinations and reactions take place upon the calcining of raw materials, and also when the cement is mixed with water and allowed to set. So there is nothing in the fundamental principles of Portland cement-making in which one manufacturer can claim superiority over his rivals; no secret processes, no patented methods; and his only chances to win the race of keen competition lie in natural advantges of raw material, location of plant, cost of fuel, choice of mechanical appliances, and price of labor."

Mr. Green gives an elaborate comparative review of the Portland cement industry in various countries, beginning with England, and including France, Germany, Belgium, and other countries of Europe, and devotes the conclusion of the paper to the American cement industry, with especial reference to its recent development. Since 1891 the proportion of manufactured to imported cements in the United States has been rapidly increasing, and, as more attention is paid to testing and investigating the various products instead of depending merely upon manufacturers' names and past reputations, the

local product has rapidly gained in use.

At the present time Germany is the greatest producer of Portland cement, 38.4 per cent. of the total output being from that country, while England, formerly in the lead, now holds second place, with 23.7 per cent., after which come France, with only 8.6 per cent., and the United States, with 6.6 per cent.

The demand for Portland cement the world over is rapidly increasing. In all the principal producing countries the factories are overstocked with orders, and hardly know how to fill them. European makers are not seeking the American market so anxiously, partly on this account and partly because they have to meet fierce competition from the American factories. Practically all the American product is used at home, while that of England and Germany is largely exported. The American establishments now supply about one-half of the domestic consumption, but at the present rate of increase it seems probable that the foreign brands will before long be almost entirely supplanted by the American cements, and that they may even attempt to seek foreign markets as well.

Electrical Vision.

THERE has been much talk recently about the alleged discovery of the Polish inventor Szczepanik in the line of vision at a distance, and the "telelectroscope," as the apparatus has been called, bids fair to be the next object of scientific and popular interest.

Although no full disclosure has as yet been made of the method used in the new apparatus, an article on the general subject of electrical vision, in a recent issue of the *Scientific American Supplement*, gives the present state of public information upon the subject, together with as much as is known upon the subject of Szczepanik's invention.

The fundamental principle of the apparatus, as might have been expected, is the variation in the electrical conductivity of selenium, under the action of varying light. The simplest demonstration of this property is that of including a selenium "cell" in a telephone circuit, causing a sharp click to be heard in the telephone-receiver every time a bright ray of light is allowed to fall upon the selenium.

"The discovery of Szczepanik, in brief consists in allowing the rays emanating from the object to fall upon a cell of selenium. Electric impulses will be produced in the selenium, whose intensity depends upon the brightness of the rays falling upon the cell. These impulses, being conducted to a distant receiving station, are there transformed again into light. The rays which fall upon the selenium are first separated into points of light by oscillating mirrors in the transmitting station. Similar mirrors in the receiving station vibrate synchronously with the mirrors of the transmitting station, and reproduce the image of the object."

"The retina of the human eye possesses the peculiarity of being sensitive to a light impression, even after the source of light has been extinguished, and for this reason it is that the unusually rapid vibrations of the mirrors are perceived simultaneously, and produce an image which is the exact representation of that transmitted from the first station. We have all seen how a spark on the end of a match, when rapidly swung around in a circle, produces the impression of a ring of light. In an exactly similar manner, the rapidly-succeeding points of light falling from the object upon the mirrors apparently produce an image of the original object. The question then naturally arises: Is it possible to oscillate the mirrors with sufficient rapidity to produce a series of points which, following one another with such rapidity, will cause a picture of the object to be produced."

The mirrors are arranged in pairs at right angles as regards their vibrations, and hence the number of points projected on the selenium in the transmitter will be equal to the product of the number of oscillations performed by each of them. If, for example, each mirror swings on its axis only 100 times in a second, then 10,000 points of light will in a like period fall upon the selenium, and be transmitted. As a matter of fact, the image points may

number hundreds of thousands, or even millions. So rapid are the oscillations of the mirrors that the tenth part of a second is sufficient to analyze the image of an object in the transmitter, and to render it visible at the receiving station. It is therefore possible to transmit a continuous action, such as a theatre performance, over the wires of the telelectroscope, since the pictures received follow one another so rapidly as to produce the impression of a moving image, just as the numerous separate pictures of a chronophotographic apparatus reproduce past actions."

In the article referred to diagrams are given which are supposed to show the arrangement of Szczepanik's apparatus, but it is announced that the full details of its construction and operation are not to be divulged until it has been exhibited at the Paris exposition in 1900.

The Thermo-pile as a Fog Signal.

NUMEROUS disasters at sea have shown that the most dangerous element in modern transatlantic navigation is fog, not only because of the obstruction to visual lookouts and signals, but because the only substitute hitherto used as a substitute for sight—*viz.*, sound—has proved both insufficient and deceptive.

Very recently a suggestion has been made by Mr. Hermann Herberts, in a communication to the *Electrical Engineer*, to substitute the very delicate thermo-electric pile for the siren, eophone, and other acoustic devices, and to attempt to determine the presence of approaching objects by differences of temperature.

It is well known that any object, when its temperature is higher or lower than that of the atmosphere surrounding the same, will either send forth heat radiations, or else, in the other case, absorb heat from its surrounding medium.

If we can construct an apparatus which is acted upon by such heat radiations, and if the apparatus be so sensitive that it will indicate the radiations, even if they be exceedingly weak, then we have a means which may be advantageously employed in navigation. As soon as we can intercept the radiations sent forth from a vessel, we need not depend upon our eye or ear to locate the same. A modification of the thermo-pile or the radiophone may be employed in connection with this problem.

The apparatus, as now suggested, consists of two thermo-piles attached to a vertical spindle, so arranged that they can be rotated slowly, and thus exposed to radiations coming from any direction. A galvanometer enables any variation in current to be seen, and a connection with a bell gives also audible warning. Under these conditions the approach of any warmer body, as a steamship, or any colder body, as an iceberg, will have sufficient effect upon the thermo-piles, even at a considerable distance, to enable precautions against collision to be taken. By observations upon the position of the piles, and upon the increasing or diminishing effect of the radiations, the location and direction of motion of the vessel may be determined, and, as these effects are independent of atmospheric conditions, experiments conducted in clear weather can be used to calibrate instruments to be used afterwards in fog.

A number of details about the proposed apparatus are shown in the communication above referred to, and doubtless modifications may need to be made as a result of experience, but the method certainly offers possibilities not existing in the present ineffective fog-signal methods, and deserves to be submitted to every practical test necessary for its complete demonstration.

The Transmission of Power.

THE transmission of power from the point of generation to the point of application forms so important a feature in nearly all manufacturing establishments that it is always a fertile theme for discussion.

A general topical discussion upon this subject was held recently by the Western Society of Engineers, and from the report in the *Journal* of the society some interesting details are taken.

The discussion was divided into three parts, considering respectively the electri-

cal, pneumatic, and mechanical methods of transmission; the latter title being intended to include shafting, belting, ropes, and similar devices.

Taking first into consideration the use of electricity, as available for power-transmission in a factory, there seemed to be little doubt as to its convenience and advantage. Even for driving heavy machinery, the electric motor has shown its capacity, and the statements of Professor Jackson, and also of Mr. E. B. Clark, of the Illinois Steel Company, demonstrated the entire applicability of electricity for heavy rolling-mill work.

For general purposes electricity will probably cost more than shafts and belts, or shafts and ropes, but for many special purposes the first cost of electricity is no greater than the first cost of other transmitting agents which will do the work. There are many places in which shafts and belts, or shafts and ropes, cannot serve satisfactorily. In the latter places electricity has often displaced other means of transmission; and there are now numerous manufacturing establishments in the United States, which turn out a heavy or bulky product, in each of which considerably more than one thousand h. p. of electric motors are in use, driving general machinery. There are some plants which individually use more than two thousand h. p. in electric motors. In these cases the electrical machines have almost invariably replaced the older methods of transmission with success and advantage, as is shown by the fact that electrical transmission is being increased in magnitude in almost every one of these plants.

In summing up this question, Professor Jackson says:

"In constructing new manufacturing plants, the extra cost of a complete system of electrical transmission for the works is negligible (except under peculiar circumstances), compared with the annual savings effected by its means when its advantages are properly utilized.

"In certain industries the advantages of electrical transmission outweigh the first cost of making a change from mechanical to electrical transmission in established plants, while in many plants where this condition would not commonly exist the arrangement of the buildings or the growth of the plant is frequently of a character, with reference to the prime power plant, which places electrical transmission upon an advantageous footing, either as an auxiliary to the main transmission or as a rival to the existing mechanical transmission."

Passing now to the use of compressed air as a means of transmitting power, its availability appears to lie rather in the special work for which it is adapted than to the general transmission plant.

The extending use of pneumatic tools for chipping, caulking, riveting, etc., together with the convenient forms of pneumatic lifts, blowers, and cleaning devices, all make compressed air a most convenient medium of power-transmission in many establishments.

In some instances air is the only medium which can be used, and the enormous capacity of the pneumatic painting device, as used in painting cars, is an example of the manner in which labor may be saved, one man doing the work of ten with this device alone.

Compressed air appears to be especially applicable for intermittent work, and in this respect it has the great advantage that it does not require the continual operation of the compressor, unless the demand is great. When the storage is not being drawn upon, the plant can be shut down absolutely, the reservoir with the power remaining at hand for use. This is of great advantage in a place where but a small amount of compressed air is used occasionally. In such instances a few hours' work of the compressor will compress all the air necessary, and the inconvenience and expense of continuous running are avoided.

In the face of the advantages shown by electricity and compressed air, it almost seems as if shafting, belting, ropes, and pulleys would soon be relegated to the past.

For extended transmissions this is undoubtedly the case. Engineers have realized for a long time that the power con-

sumed in transmission formed a large percentage of the total, even in the best-arranged establishments. In the discussion above referred to, Mr. H. J. Westover showed from actual tests that the ratio of the useful load to the full load in a number of establishments ranged from a little more than 60 per cent. to a little less than 30 per cent., and it is undoubtedly true that in most cases more than one-half of the power generated is consumed in overcoming the transmission resistance.

For many limited purposes, however, shafting and belting, or other mechanical appliances, will doubtless continue to be used. The manufacturing establishment of the near future will probably use all three methods in proportions varying with the nature of the work.

Primarily, all the power of the engines will be converted into electricity, and, as such, transmitted to the various parts of the establishment, to be used either directly or indirectly. Many heavy machines will be provided with their own motors, and probably the greater part of the current will be thus used. In some cases "group"-driving will be found more advantageous, and short lengths of shafting operated by electric motors will distribute the power by belts or ropes. When, in addition to this, we have an air compressor, conveniently operated by a motor, to supply compressed air to the special tools requiring it, we have a power plant at once convenient, flexible, and economical, and in nearly every case superior to any one of the three systems used alone.

Pneumatic Dispatch Tubes.

THE development of pneumatic dispatch tubes, especially for the local handling of mail matter, forms the subject of a paper by Mr. B. C. Batcheller, read before the Franklin Institute, and published in the *Journal* of the Institute. As the author has been closely identified with the subject in the United States, he is entitled to speak with the confidence which comes only from experience.

Pneumatic tubes of moderate diameter have been used for a number of years, especially for the transmission of messages. London, Paris, Berlin, and Vienna for years have had their pneumatic-tube systems for transmitting telegrams between the central and branch offices.

There has been much misconception of the size, capacity, length, and use of the tube sytems of Europe, and Mr. Batcheller states that the largest tubes used in London are only 3 inches in diameter, while those of Paris and Berlin are about 2¼ inches. No mail is sent through these tubes, as they are not large enough for the purpose; they are used only for the transmission of telegrams and messages.

The United States was much behind the various countries of Europe, in point of time, in the use of pneumatic tubes, but, almost from the start, undertook operations on a much larger scale.

The first tubes, 6 inches in diameter, were laid in Philadelphia for the dispatch of mail matter from the sub-station post office in the Bourse to the main post office, a distance of about 3,000 feet. Several difficulties present themselves in connection with the large carriers required for mail matter; such as friction, due to the increased weight, and the inertia, requiring provision to be made for the stored energy in the carrier in bringing it to rest. These have been successfully overcome in practice, and the Philadelphia tube has been in satisfactory operation for more than five years, and is still in daily use. The system involves a double line of tubes, the air flowing continuously through one tube and returning through the other, the return end connecting with the suction of the compressor. The arrangement is a pressure system, a pressure of about 7 pounds per square inch being employed.

Since the introduction of the Philadelphia plant several extensions of it have been made, and in New York an 8-inch system has been installed with success, and a similar one since in Boston. The 8-inch carrier used in these tubes weighs 13¾ pounds, and will carry 600 ordinary letters. Many interesting details have been evolved in the practical development of the system, and the arrangement of the sending and receiving apparatus is well illustrated and described in the paper.

The Niagara Hydraulic Power Plant.

So much has been said and written about the harnessing of Niagara by the great work of the Cataract Construction Company, with its shaft, tunnel, and Swiss turbine, that it is worth while to take a look at another power installation which derives its energy from the great cataract in a much simpler and, to many minds, more practical manner.

The Niagara Falls Hydraulic Power and Manufacturing Company, whose plant is described and illustrated in a recent issue of the *Electrical Engineer*, obtains its supply of water from the old hydraulic canal, constructed many years ago, which conveys water from the Niagara river above the Falls, through the city, to the brink of the gorge below the great cataract. For a long time the water from this canal was most imperfectly utilized by a number of mills along the edge of the gorge, only a small fraction of the possible fall being used, and the wasted water being allowed to expend its energy in miniature cataracts falling down to the rapids below.

In order to utilize the entire fall of 214 feet, from the level of the canal to the lower rapids, the Hydraulic Power Company has built its power-house in the gorge close to the lower level, and carries the water through two huge steel penstocks from the upper level to the wheels.

This arrangement entirely avoids the necessity of using the heavy vertical shafts which form so important a feature of the Cataract Company's plant, the generators being placed in the power house at the foot of the gorge and the energy conveyed to the upper level in the form of electric current.

The turbines of the Jonval-Geyelin type, were designed by the veteran hydraulic engineer, M. Emile Geyelin, of Philadelphia, and constructed by Messrs. R. D. Wood & Co. They are of the horizontal type the water being admitted between two wheels on the same axis and discharged on each side, draft tubes being provided in order to enable the total head to be utilized down to the level of the tail race. The armatures of the generators are placed directly upon the horizontal turbine shafts, and the whole plant is characterized by a direct and straightforward simplicity which appeals in a peculiar manner to the engineer.

During the recent convention of the American Society of Mechanical Engineers at Niagara Falls abundant opportunity was given to the members to inspect both this and the plant of the Cataract Company above the Falls, and it was most interesting to observe the manner in which the two installations were viewed by these observant and competent critics.

The great shaft, tunnel, and generators above the falls were admired on all hands, and the skill with which the many difficulties had been overcome was praised. When, however, the unpretentious power-house in the gorge was visited, and it was seen how difficulties had been avoided rather than forced, and how, at a fraction of the cost, fully as much power was rendered available as at the world-famed plant above, there was nothing but admiration for the skilful manner in which existing facilities had been seized and a great plant created at a comparatively insignificant cost. It was a lesson which many were not slow to grasp, and which was repeated again and again during those few days.

An interesting feature of this plant is the use of aluminum conductors to convey the electric current from the generators in the power-house to the distribution. More than 22,000 pounds of aluminum are used in this installation, and, although a greater section is necessary than for copper, yet, weight for weight, the conductivity is double that of copper.

The work at the Niagara Falls Hydraulic Power and Manufacturing Company's plant has all been done under the skilful supervision of Wallace C. Johnson, and reflects the utmost credit upon his judgment and ability as an engineer.

Power from Producer Gas.

In advocating the use of gas engines we have frequently referred to the various methods of generating producer gas, and especially called attention of late to the applicability of blast-furnace gases for this

purpose. At the present time there are several excellent forms of gas producers,—or *gazogenes*, as the French call them,—which are well adapted for use with gas engines. In describing the results of some tests upon such apparatus, in an article in the *American Machinist*, Mr. W. H. Booth brings out some interesting features. The sources of loss in using producer gas in a gas engine are principally the radiation of heat from the producer, and the loss of the heat carried away in the jacket water of the cylinder and with the exhaust. It is practically impossible to prevent these losses, so far as the producer and the engine are concerned. If the cylinder was not provided with a water jacket, it would soon become too hot to work, the piston would seize, and the cylinder would become red-hot from the successive explosions; while the high temperature of combustion which makes the efficiency what it is necessitates a high temperature of exhaust.

In one of the cases referred to by Mr. Booth, however, the circulating water in the cylinder jacket was found just the thing for use in the dye-house, while the hot exhaust was used both for drying and also for heating the blast for the gas producer; thus these usual sources of loss were utilized in a very effective manner.

Mr. Booth makes out some very strong points for the gas engine and producer as a power-generating plant, when intelligently managed.

"Even at its worst, throwing away all the jacket heat, a gas engine is a much more efficient heat engine than a steam engine. By means of the gas producer it is able to use coal of a very low quality. Common gas coke, dirty slack coal, peat, and almost any combustible, especially if mixed suitably, will produce gas fit for a gas engine."

"It seems very certain that the gas engine is destined, in conjunction with the gas producer, to play a large part in future motive-power production. We need not shut our eyes to the manifold disadvantages of the gas engine to be assured of this. Indeed, if we recognize these disadvantages, the more we must admit how much the gas engine has already overcome, and what a field there is for its improvement."

Until recently gas engines have been used only in moderate sizes, but the growing interest in the subject has caused builders to turn their attention to engines of large size, and now a number of gas engines of more than 200 h. p. are in use.

Mr. Booth gives some interesting figures of a large engine in use at Birstall, Scotland, operated by producer gas, which are of value as showing the general performance which may be expected. The gas, which was made from coal and coke mixed, contained about 25 per cent. of carbon monoxide, from 6 to 7 per cent., of hydrogen, and 1 to 2 per cent. of methane. Using this mixture in a gas engine, with a compression of 80 pounds per square inch, an initial cylinder pressure of 208 pounds was obtained, and a mean effective pressure of 88 pounds per square inch. The power developed ranged from 100 to 150 h. p., with a gas consumption of 97.5 cubic feet per h. p. It is estimated that the fuel cost per h. p. is only $1\frac{1}{4}$ pounds per hour, using low-grade slack mixed with coke.

While there are at present various objections to the use of gas engines, none of these can for a moment be admitted to overbalance the superior economy of this form of motor over the steam engine. Instead of finding fault with the weak points of the gas engine, its good features are so strong that we should encourage our ablest engineers to overcome all objections to the use of so economical and valuable a source of power.

THE BRITISH PRESS

The Launch of the Amphitrite.

THE enormous extent of England's naval construction is suggested by the quiet with which the many important launchings of the summer have been regarded. Events which would stir a smaller naval power through and through have been accepted as incidents, merely, in a programme whose magnitude would startle any other nation of the eastern hemisphere or the western, but which is yet regarded as inadequate by some critics.

And naval construction, after all, is but one element in an industry by which "the sea is England's glory" in the sense that her shipbuilders, no less than her sailors, have taken a leading part in making it the safe and busy high road of the world.

It is, therefore, interesting to notice the indications afforded by these latest incidents of the *rapprochement* of the mercantile and naval schools of marine engineering and architecture. Those who witnessed the magnificently-successful launch of the Amphitrite at the works of Messrs. Vickers, Sons and Maxim, Barrow-in-Furness, and had an opportunity to study her lines and her queenly appearance when afloat, were quite prepared, first, for Sir William White's statement that, in his estimation, she is his most satisfactory ship, and, second, for his comment upon the return to the graceful and beautiful lines which, at one time, seemed to have disappeared from naval construction. The warship of (say) twenty years ago was perhaps a thing of terror, but certainly not a thing of beauty. The tendency to ugliness rapidly reached a maximum after the complete discarding of sails, with the resultant creation of fighting vessels whose very appearance was a nightmare and gave rise to much of the impression that steam had driven beauty and romance from the sea.

The later and saner reaction, made strikingly apparent in the Amphitrite, and, as Mr. H. W. Wilson has recently remarked in these pages, in all Sir William White's ships, is based upon appreciation of the fact that naval effectiveness depends, after all, upon stability, seaworthiness, and (as Mr. W. Laird Clowes so ably argued in THE ENGINEERING MAGAZINE for July) speed. These are distinctly engineering propositions, which the evolution of centuries has shown to be associated with graceful lines above and below the water. Of course, here or elsewhere, custom and convention may have much to do with our standards of beauty, and, if so, we may ere long learn to miss less the tall spars and sails of the frigate, and find a similar satisfaction in the contemplation of the modern superstructure.

The warship presents many grave and difficult problems which the naval designer must face; with the disappearance, however, of the idea that she must therefore be a circular tank or a huge, misshapen pontoon, the arts of the merchant shipbuilder and the naval constructor grow profitably closer together, and opportunity opens for most advantageous coöperation of marine engineers in both branches.

Sir William's "crawling cruisers"—crawling, as he humorously suggested at Barrow, at the rather un-snail-like pace of 20 knots—are exponents of an era; the esthetic characteristics, to which he called attention, are indicative of important underlying mechanical and economic conditions.

Safety at Sea.

IN view of recent disasters at sea, the ever-recurring question of the best methods of protection is again being agitated. Unfortunately, the greatest sources of danger are those against which as yet no adequate defence has been devised, but there are at least certain precautions which may be taken.

A recent editorial in *Engineering* reviews the most important precautions to

be taken by vessels crossing the Atlantic, and some of the points made cannot fail to be of interest at the present time.

"The chief danger that has to be faced by those making voyages in well-appointed steamers is collision; if we add strandings, we almost fill the list. The steam engine has made navigation independent of the direction of the wind, and the size of modern vessels, combined with the use of steel as a material of construction, enables the modern ocean liner to pursue its course safely through the heaviest storms. We have, of course, occasional break-downs of machinery, notably of propeller shafts. These correspond to the old carrying-away of sails and spars; but, whereas the integrity of the rigging of a sailing ship was a constant source of anxiety in heavy weather, engines work through calm or storm indifferently, so long as racing is prevented." Fog increases the danger of collision, and it is against fog that the greatest precautions need be taken. Masters of vessels are instructed to slacken speed in thick weather, but the slackened speed of a record-breaker is scarcely less than the full speed of an ordinary liner, and every captain knows that he is expected to keep time, fog or no fog; the passengers themselves would be among the first to complain, if the voyage appeared to be unduly prolonged. Besides, the plausible argument is made that, the higher the speed, the sooner the fog-area is crossed. The speed makes but little difference in the damage, if the ship is fairly struck, and, the sooner the fog belt is past, the sooner the danger is over.

The great objection to speed in a fog lies in the difficulty of hearing and judging relative positions; there is undoubtedly a better chance of being heard when going at a slow speed than when making eighteen or twenty knots.

The latter speed means that a nautical mile is covered every three minutes, and, although a foghorn may be heard a mile distant, it is very difficult to judge of the direction from which the sound comes until it is near. The result is that the location of the source of danger is often out of the question, until it is too late to avoid a collision, or, if actual contact is escaped, it is not because of any human control of the situation.

Attempts have been made to construct sound tubes pointing in different directions and supposed to give some clue, by the variation in intensity, to the direction from which the sound comes; such devices are, at best, but attempts to use an imperfect source of warning. A more promising idea is that recently proposed,—to use the indications of the very sensitive thermopile to give warning of an approaching source of heat. As the heat of a candle has been detected by this device at a distance of a quarter of a mile, it is not improbable that a steamer might be discovered much farther off.

So far as the best protection in case of collision is concerned, there seems to be little doubt that it should be in the ships themselves. It is practicable to construct a ship so that it may remain floatable after it has been freely opened to the sea. Bulkheads may have their great inconveniences, and are too often improperly placed, but the fact remains that great steamers have come safely to port with hulls damaged to an extent which would surely have sent them to the bottom, had it not been for the bulkheads. Danger at sea can never be wholly prevented, but many precautions may be taken, both in construction and in navigation, to render accidents not only very infrequent, but—what is far more important—free from fatalities.

The Depreciation of Machinery.

IN investigating the true financial condition of a manufacturing plant, the valuation to be placed upon the machinery is always a difficult question. Some maintain that its value should be based upon its earning capacity; others that it is worth no more than the cost of its present replacement; while in still other cases it is found that machines which a few years before were valuable assets have become of little or no value, because they have been superseded by other and far more efficient devices. These and other interesting points concerning depreciation for the subject of a recent editorial in *Engi-*

neering, from which we make some abstracts.

"For a long time it was customary—indeed, it is so still—to write off annually a given percentage of the value of machinery, as shown by the last year's balance-sheet. This causes a rapid depreciation at first, but the rate soon diminishes, until it scarcely varies at all, and this just at the time when the tool is really depreciating most rapidly. The result is that many large plants are becoming almost hopelessly antiquated, and, while the books show it to possess a good valuation, its earning power is *nil*.

"The ordinary methods of reckoning depreciation take no account of the important fact that machines grow yearly more specialised and more expensive. The lathe costing 200*l*. has to be replaced by one worth 400*l*., or more, and no system of percentage on last year's book value will provide for this. It is only by writing off a fixed sum annually that the case can be met. The so-called absurdity of a machine being credited with a negative value is not an absurdity at all, when it is remembered that its successor will probably cost twice as much as it did. A manufacturing business cannot be run on the principle of gradually writing off all the capital, and then allowing it to drop. Much money has to be expended in directions from which it cannot be withdrawn. Reputation has to be created, and the confidence of customers to be obtained; and both these cost money. Any attempt to trade upon them by turning out inferior goods deteriorates them most rapidly, and, even when unimpaired, they are scarcely ever salable to another person for what they have cost.

"Business is like a race; the entrance money is only returned in the form of prizes. The man who drops out gets nothing back. Once a man has embarked his fortune in manufacturing, he can only regain it by being successful. He must constantly find more and more capital, and spend increasing sums on machinery; every year this necessity becomes more urgent."

A very important factor in the depreciation of machinery is the restless mental activity of the age. Thousands of people are devoting their lives to the improvement of machinery, and the modern tool loses its value almost as rapidly when running as when idle.

"It is by no means likely that we have seen the worst—or the best—of this process. The pace has perceptibly quickened during even the past ten years, and it is certain to get still faster in the next decade. America leads the way in a fashion which is absolutely staggering. In her iron and steel works money is poured out like water on new machines. Old plant is thrown out as a matter of course, and the manufacturer who cannot find money to purchase new gets squeezed out of the trade, although his works may be perfectly equipped for every purpose, except that of making a profit."

It is impossible to say just how much every machine should be depreciated, for there is no general rule possible. Some standard machines maintain their usefulness for a long time, while other and newer machines may be rendered obsolete in a short time by the introduction of some improved tool capable of doing the same work at a fraction of the cost.

"The days of enormous profits are past, and for that reason every part of a plant must be worked at its highest efficiency. The machine that does not earn a profit is merely a useless encumbrance, however satisfactory it may be to look at, and it is actual economy to break it up with a sledge-hammer rather than to keep it filling up valuable space. This is a condition to which every machine comes in time,—often in a short time,—and, unless the owner has accumulated money to replace it by a better and a more expensive one, he has been living on his capital, whilst deluding himself with the idea that he was only spending his profits."

High-Pressure Steam at Collieries.

THE tendency to use high-pressure steam appeared first in marine practice, and there are few steamships of any pretensions to modern equipment which are not now operated at pressures of at least 160 pounds per square inch. In station-

ary practice, however, the introduction of high pressures has been more gradual, and, while some power plants are now running with high-pressure steam, in the modern sense of the term, very few collieries have as yet commenced the practice.

The desirability of using high-pressure steam in collieries is discussed in a paper by Mr. Hugh Bramwell, presented before the British Society of Mining Students, and published in the *Colliery Guardian*, and some of the points which he makes as peculiar to the conditions of colliery practice are worthy of consideration.

"At the outset it may be stated that colliery surface arrangements do not generally lend themselves readily to steam at such pressures—150 pounds and over. In cases of mills, engineering works, and electric light or power stations, the boilers can usually be placed immediately adjoining the engines they supply, and consequently all steam pipes can be kept within the buildings themselves. At most collieries, on the other hand, conditions exist necessitating the conveying of steam to various parts of the premises and entailing long lengths of more or less exposed steam pipes. Owing to the greater changes of temperature, the nature and care of such pipes are very different matters with high pressures from those experienced with pressures of about 50 pounds per square inch."

The economy in fuel, however, in most cases amply repays the cost and trouble involved, there being a decided gain both in the generation and in the application of the steam.

For the generating plant one still has the choice between shell boilers of the Galloway or Lancashire type, and water-tube boilers, such as the Babcock & Wilcox; the nature of the feed-water will generally have much to do with the choice. The larger area of grate obtainable with water-tube boilers renders them well suited to colliery service, as inferior qualities of fuel may be more readily burned, and high pressures can be carried with safety.

Cast-iron pipes are inadvisable for high-pressure service, and mild steel lap-welded tubes with welded-on flanges are recommended.

Plenty of bolts must be used in the flange joints, placed as close together as is practicable, since tightness cannot otherwise be obtained. The high temperature makes india-rubber gaskets useless, and some form of asbestos packing is recommended, preferably in connection with metal rings, either of copper or brass. An excellent packing is made of lead and asbestos cord, consisting of a small lead pipe covered with woven asbestos.

The necessity of making proper provision for expansion is much more imperative than it is with steam at lower temperatures, and care should be taken to avoid rigid hangers or supports. In draining the water of condensation the flow should be in the direction of the steam flow, if possible, and traps or separators should be provided at various points. Float traps are not so well adapted for this service as expansion traps, as the danger of collapsing or infiltration of water is greater, and the expansion traps answer well for the high range of temperature.

The covering of the pipes is a most important point, and the necessity of conveying steam long distances renders it imperative that condensation be reduced to a minimum. The economy apparently obtained by using a cheap non-conducting covering is soon over-balanced by the loss from condensation. There are greater differences in the non-conducting properties of the various pipe-coverings than one at first realises. By paying rather more in the first instance it is frequently possible to obtain an article having twice the efficiency of the cheaper forms, and this is of considerable importance with high temperatures. In addition to the immediate non-conducting covering, the steam pipes should, as far as possible, be under cover in separate culverts or passages.

In order to obtain the full economy practicable with high-pressure steam, it is imperative that the expansion be performed in two or three cylinders, and, in addition to the economy thus obtained, the excessive strains which would other-

wise occur are prevented. Colliery engineers must be prepared to compound all engines. Winding engines are the only class as to which there need be any difficulty or doubt. Owing to their intermittent working, they are, at best, extravagant steam-consumers, considering the work done, and they must be under complete control. Compound winding engines are in successful operation in Germany, however, and it does not appear that the difficulties are greater than those involved in the construction and operation of compound locomotives.

There seems to be little doubt that there will be a continual tendency toward the use of higher-pressure steam in colliery practice. While the change may not come so suddenly as it did in marine service, it must be counted upon, and the above points include the principal features which must be considered in order to render the application successful.

The Present Status of Acetylene.

AMONG the important papers presented at the Belfast meeting of the Incorporated Gas Institute, that of Mr. Vivian B. Lewes upon "Acetylene and Its Modern Developments" is especially worthy of notice, as Mr. Lewes, who contributed largely to the prominence given to acetylene when it was first brought before the public, is therefore well acquainted with the history of the development of the subject.

Since the Edinburgh meeting in 1895, when the attention of the institute was first directed to acetylene as a commercial illuminant, many things have occurred to alter the position which it occupies. "Reputed dangers have vanished into the air, and unsuspected ones have taken their places; many schemes have been proposed, but the home office and the insurance companies have disposed of the majority of them; the question of cost has descended from the realms of transatlantic fiction to the concrete form of solid fact; and, now that the history of the gas has reached a stage which enables one to speak with something like confidence as to the part which acetylene is likely to play in the future, it needs no further excuse for again choosing it as a subject of interest."

The first important point which has become perfectly established is that it takes about two electrical h. p. per hour to produce one pound of calcium carbide; hence the cost of acetylene is well defined. If electricity is to be used, the cost of carbide at the works can hardly be less than £16 per ton, which probably means, in most localities, £20 per ton delivered; and the efforts which have been made to produce the carbide by other means than the electric furnace show that at present such methods would probably be more costly than electricity.

Taking the average production of a ton of carbide as 11,200 cubic feet of acetylene gas, and allowing the value of the lime as a by-product to pay for the water and labour, we have the cost of the gas as practically 30s. to 40s. per 1,000 cubic feet, according to the price of the carriage of the carbide.

Under these conditions of cost, the uses of pure acetylene are so limited that it can at present only be considered in connection with some diluent which shall make it fall within the commercial limits of competition.

The most successful results in this respect are those which have followed the experiments of the firm of Julius Pintsch in Germany, by whom mixtures of oil gas and acetylene have been tested in many ways for the purpose of lighting railway-carriages. Many of the State railways in Germany are now lighted by this means, and, the safety of the mixture, even when subjected to a pressure of 10 atmospheres, having been demonstrated, its use is now permitted in Great Britain.

Photometric tests show that the addition of 20 per cent. of acetylene to oil gas doubles the illuminating power. Based on a price of £20 per ton for carbide, delivered, this makes a cost af about 14s. per 1,000 cubic feet for the mixed gas as against 8s. for the oil gas alone; as the illuminating power is doubled, the economy plainly appears. Another advantage which follows the increase in illuminating power is the greater length of time which

may be permitted to elapse between the charging of the cylinders, besides which less condensation and smoking appear than with oil gas when used alone.

Instead of using oil gas mixed with acetylene, Mr. Lewes suggests the use of methane as a diluent, and the low cost of methane leads him to believe that this may be a very desirable mixture. By using a slightly-modified form of water-gas generator, he is able to produce a diluting gas containing 30 per cent. of methane and 45 per cent. of hydrogen, having an initial illuminating effect of 10 to 12 candles, and costing 8d. to 10d. per 1,000 cubic feet. Mixing this with about 5 per cent. of acetylene, a gas is obtained having an illuminating value of 18 to 20 candles, which, being regarded as a mixture of perfect gases, gives no trouble as regards layering, and which, having the same specific gravity and illuminating power as coal gas, can be distributed and burned in precisely the same way. It is also found that mixtures of this gas with 50 per cent. of acetylene are not detonated, when compressed for railway-carriage-lighting purposes, at any temperature which it would be possible to attain in the cylinder; and it seems that this method of utilizing acetylene is pre-eminently the one which promises for it the largest and most remunerative future.

The Purification of Drinking-Water.

AT the meeting of the British Association of Water-works Engineers at Southampton an interesting paper was read by Dr. Percy Frankland on the chemical and bacteriological examination of water, and, although no very novel views were offered, the whole formed an excellent and authoritative presentation of a very important subject.

It was first shown that, while chemical examination might reveal the presence of injurious constituents, negative results were by no means an assurance of the purity of the water, as a bacteriological examination might show it to be unfit for use.

Many waters are available in large quantity which, although undoubtedly contaminated with sewage matters, are still contaminated to so slight an extent that chemical examination fails to detect any danger. Such waters, however, need not be wholly avoided, but can be rendered suitable for domestic use by some simple process of purification, such as storage in large reservoirs or filtration through fine sand.

In order to show the efficiency of sand filtration in removing bacteria, Dr. Frankland cites the average number of bacteria found in Thames water as supplied to London before and after filtration, and shows that in no case was the reduction less than 96 per cent., while in most months it exceeded 99 per cent. In the month of January the average number of bacteria in one cubic centimetre was 92,000 before filtration, while, after filtering, this was reduced to 129. Similar results were shown for other months.

The proper way to ascertain whether filtration is being properly carried on is to maintain a continual bacteriological control. A new sand filter is comparatively inefficient; the filtrate should be permitted to run to waste, until an examination shows that the sand has acquired the power of retaining the micro-organisms in the water, and a similar practice should prevail every time the filter-beds are cleaned.

"Just as the bacteriological examination has enabled the real value of artificial purification processes to be ascertained, so also by its means can it be discovered whether or not natural purification processes are operating with efficiency. Thus the safety of deep-well water depends upon the exhaustive filtration to which it has been subjected in the porous strata of the earth; and, if the water gaining access to such a well has really been thus filtered, it should be almost entirely free from bacteria, and this, in regard to properly-constructed wells, is found actually to

An important feature in connection with sand filtration, and one which is often imperfectly appreciated, is the necessity of a constant rate of filtration. Sudden changes in the rate, or shock in flow, are

most injurious, and must be carefully avoided, and all attempts at forcing the rate must be prohibited. The filters must be independent of the varying consumption, sufficient storage of purified water being provided; thus the steady, uniform operation of the filter beds need not be interrupted or modified in any way between the periodical cleanings.

There seems to be no doubt that sand filtration affords an effective means of rendering water-supplies available for municipal use when they would otherwise have to be rejected, and the precautions urged by Dr. Frankland serve only to show the effective nature of the process when properly installed and maintained.

The Outcome of Sanitation.

A VERY instructive review of the outcome of the work in sanitation done in England during the past sixty years is found in a lecture by Dr. Louis C. Parkes, published in the *Journal of the Sanitary Institute*.

Starting at the beginning of the present reign, Dr. Parkes shows how the very complete and accurate registration commenced at that time has resulted in the production of a mass of data from which we have been able to learn much concerning the sources of disease and the sanitary methods of prevention.

Not only are we now in possession of the facts as to the mortality from different diseases, but, owing to the immense studies made in the medical and allied sciences, we now recognise many of the direst diseases and worst scourges of the human race as preventable by properly-administered methods of sanitation, and we have already gone a considerable way on the road to completing such methods.

At the risk of going somewhat into medical statistics, we may note some of the successes made in fighting disease during the period under consideration. The death-rate from smallpox has diminished 96 per cent., and that from fevers 82 per cent.; tubercular diseases have had their death-rate diminished 46 per cent.; diarrhœa, 30 per cent. The only disease which has not shown a reduction in its death-rate is diphtheria, which is about the same as it was thirty years ago (1861–1865), and is about double the rate prevailing in the fifteen years 1866–1880. The death-rate for England and Wales has diminished from 22.4 per 1000 in 1841 to 18.7 per 1000 in 1895.

The share which sanitary engineering has had in producing these favourable results is undoubtedly large.

First among them may be named pure water-supplies. A very large number of polluted sources formerly freely used have been replaced by improved works, and all the principal towns of the country are now supplied with water of exceptional purity, as are also many rural districts; the millions sterling spent in these magnificent enterprises are among the most beneficial outlays of the country's wealth.

The sanitary methods of sewage disposal now in use, compared with those existing sixty years ago, have had much to do with the advances made in public health. Not only is the sewage conveyed away from the town in a comparatively fresh and innocuous condition, but its further disposal has been given much study. The right methods of disposal and utilisation of sewage have been the subject of much controversy and experiment, and it is only recently that we have come to recognise the part played by natural forces in the purification effected by the various processes now in vogue. Not many years ago the idea generally prevailed that a large volume of sewage required a large area of land for its disposal, so as to produce an effluent of sufficient purity to be permitted to pass into streams. Sewage farms, however, were found to be costly to acquire and expensive to maintain, and the return from sewage-grown produce was an insufficient set-off against these expenses. At the present time sewage can be clarified by precipitation, and subsequently purified by filtration through artificially-constructed filter beds (which are really cultivating grounds for the nitrefying organisms that effect the chief part of the purification) on an area of land which would be absolutely useless for crude irrigation.

The Wear of Chains.

WHEN we consider the important duties chains are frequently called upon to perform, and the serious consequences of failure, any contribution to technical literature which helps to increase the security of such members is worthy of notice and commendation. An excellent paper upon the wear of chains, by Mr. R. Weatherburn, in a recent issue of the *Engineer*, gives some interesting points about a feature of chains which has been too generally neglected.

The strength of new chains is a subject which has been discussed at various times, and tests of chains of various forms have been made by competent authorities, and are matters of scientific record. The fact that chains are subjected to wear, however, seems to have been generally neglected by the text-books and testing-laboratories; hence the desirability of calling attention to the causes and nature of the deterioration.

Mr. Weatherburn divides the wear into two kinds, the determinate, or visible, being local in action and due to abrasion, distortion, and movement, and the indeterminate, or invisible, being the slow, but sure, change from the fibrous to the crystalline condition in the organic structure of the metal.

Both wears are contemporaneous, but the two are not equal. The determinate wear can be dealt with only by removal and substitution, while the indeterminate can be remedied by periodical annealing.

The determinate wear can be modified very greatly by care in design, and is always greatest in ill-designed chain, as indeed in other ill-designed machines.

Acute knuckling motion of links passing around sheaves or drums of small diameter can usually be avoided, and does not occur in cranes of the best design, and the race or channel for the links in winding drums should be near enough to the size of the chain to prevent a canting or rolling motion. A twist in a chain is a frequent cause of determinate wear, and especial care should be taken, both in the manufacture and in the subsequent use, that no twist occurs. The righting of the twisted portion under load produces excessive local wear, and may reduce the life of the chain by one-half.

Defects due to imperfections in manufacture sometimes appear, and are generally made evident by unequal wear. The rapid wear of one link of a chain, or the greater wear at one end of a link than at the other, can have but one solution; there must have been some irregularity in the, working so that the metal, by more or less hammering at doubtful temperatures, has become injured.

"Indeterminate wear is not general throughout the length of chain, but is even more localised than outside wear, being subject not only to the same influences which produce outer wear,—*viz.*, weight and motion,—but also to differences of temperature, shocks, etc., which mostly affect those portions of the chain which receive the most movement. The influence of cold on the cohesion of chains is very remarkable, and should be taken seriously into account in cold weather or in cold climates. Fortunately, in spite of the insidious and dangerous character of the unseen wear, it can be dealt with much easier and more generally than determinate wear. The process of annealing, or, in other words, restoration, is so easy as to come within the range of every user of chain, although the easiness of the process may cause it to be carelessiy done. Annealing can be accomplished in a furnace, but the temperature should never be more than that represented by what is known as red; any higher visual temperature may produce scaling, which would be loss."

In order to provide sufficient elasticity, it is better for the links to be made somewhat oval in form, as this enables shocks to be taken up without causing undue stress.

It is evident, therefore, that too much dependence should not be placed upon a chain merely because it has satisfactorily passed a critical inspection, when new. Frequent periodical inspections should be made, worn parts should be renewed, and occasional annealing should be performed, if the original quality is to be maintained.

THE CONTINENTAL PRESS

Inclined-Plane Canal Lifts.

IN the discussions of the plans submitted for the construction of water communication between the Danube and the North sea, the problem of overcoming the intervening elevation has been a prominent feature. The use of the ordinary system of locks involves much delay, and adds to the operating expense, while the construction of hydraulic lifts, such as are in use at Les Fontinettes in France and at La Louvière in Belgium, increases the first cost.

An alternative scheme is that of using an inclined-plane lift; an elaborate account of such a construction is given by Victor Schönbach, in the *Zeitschrift des Oesterr. Ingenieur und Architekten Vereines*, together with the discussion which the paper received at its presentation before the society.

The canal inclined-plane is virtually a form of ship-railway, the essential feature being that it is designed to overcome a steep grade. Numerous modifications in ordinary railway construction are necessary to meet the peculiar conditions, and these special features are fully considered in the paper.

Instead of conveying the boat in a direction parallel to its axis, the direction of the lift described by Herr Schönbach is at right angles to the line of the canal, the two canal sections being parallel to each other, one, however, being placed at a higher level than the other, as the general plan of the waterway was so designed as to concentrate the entire difference in level between the terminals at a few convenient points where such construction is practicable.

The boat is carried in a tank car, the general arrangement being somewhat similar to that seen in the well-known transfer table used in railway yards and shops for the shifting of locomotive engines from one track to another. The greatly-increased weight, as well as the necessity of providing for the maintenance of parallelism of the wide structure upon the tracks, adds materially to the difficulties of the problem.

As planned by Herr Schönbach, a tank of 230×28×7 feet would be required, the total weight of which is estimated at more than 2,000 tons, the water alone weighing about 1,250 tons. It would be almost impossible to insure the equal distribution of this weight over a number of journal bearings; the design, therefore, includes the use of a special system of roller bearings, the rollers being connected in sets by endless chains, and passing under the framework by which the car is supported. Since the pressure comes directly upon the rollers, the only function of the roller journals is to keep them in place and insure their parallelism.

It is evidently possible to construct such an inclined plane with two tanks, each counterbalancing the weight of the other, but the design shown is arranged with counterbalance weights, traveling upon rails between the tracks for the roller bearings and connected to the tank cradle by wire cables.

The propulsion of the cradle is effected by electric motors acting, by means of a train of gearing, upon a rack rail, and the general details of this portion of the design are worked out in accordance with experience with heavy traction in other lines of work.

The arrangements of the tank are not greatly different from those in use with the French and Belgium hydraulic lifts, the joints at the ends being made watertight by the use of an inflatable hose packing, distended after the gates are closed and secured. The details of manipulation are practically identical with the hydraulic-lift practice.

An interesting portion of the paper is devoted to the comparative cost of the inclined plane and the old-style lock system, and the relative figures are embodied in

diagrams which show clearly just where the cost of the inclined-plane system passes that of the former practice. Taking a plane with a rise of one in five, for lifts from 10 to 100 metres, the cost, both of installation and of operation, is greatly in favor of locks for lifts up to about 30 metres, after which the two methods approach each other; while for the higher lifts,—from 80 to 100 metres,—the advantage is on the side of the inclined plane.

For ordinary work, therefore, the inclined-plane canal lift is not adapted, but in such cases as are contemplated in Germany it appears probable that the system will prove an important factor in solving the problem, now so earnestly discussed, of cheaper internal transport between the ports of the Danube and those of the North sea, both for grain and mineral traffic.

Compression in Steam Cylinders.

THE important experiments of Professor Dwelshauvers-Dery upon the nature, causes, and extent of the losses due to compression of exhaust steam in the cylinders of steam engines were noticed and discussed in these columns, at the time of their original publication. There now appears in the *Revue de Mécanique*, in which the original paper of Professor Dery was published, a critical examination of the subject by Professor Boulvin, and the two papers form a thorough and valuable investigation of this mooted question.

According to the experiments of Professor Dery, made upon the experimental engine at the University of Liége, the consumption of steam per i. h. p. increased with an increase of compression, following a law which gives a very rapid augmentation. Thus at 45 revolutions, in passing from 0 to 4-10 compression, the increase in steam-consumption is 57 per cent., and at 60 revolutions, in passing from 1-10 to 4-10 compression, it is 64 per cent.

The experiments of Professor Dery were carefully reviewed by Professor Hubert in a paper published in the *Revue Universelle des Mines*, and the conclusions reached by him were formally enunciated as follows: "Contrary to the general supposition, compression by the piston, in non-condensing engines, is injurious and wasteful, instead of being economical, and, the greater the degree of compression, the greater the loss."

In spite of the care with which these experiments were made, Professor Boulvin is not altogether disposed to accept these conclusions, and, in discussing the tests, he adds the results of experiments of his own, in order to throw some light upon the subject.

It is a well-known fact that nearly all engines of high grade in practical service are operated with a high degree of compression, and, although this is undoubtedly partly for the purpose of cushioning the inertia of the moving parts and avoiding thump, it is also found that more economical results are obtained in practice with than without compression. It is possible for engines to be so constructed that compression will not be required for the purpose of insuring quiet running, and, if any such gain as is indicated by Professor Dery's experiments were obtainable, it seems as if practical engine-builders would not be slow in endeavoring to secure so great a measure of economy.

In order to reconcile the apparent contradiction, Professor Boulvin re-examines the experiments made at Liége, applying the entropy diagram as deduced from the indicator diagrams published by Professor Dery, and the manner in which the analysis is worked out is a most instructive example of the practical application of the entropy diagram.

The paper of Professor Dery is extended by the addition of an illustration and description of the engine upon which the tests were made, and this assists very materially in explaining the points made by both investigators.

Is is plainly shown that, when the clearance space is filled entirely with live steam, and there is no compression whatever, and when the cylinder walls are assumed to be absolutely inert as regards heat, the loss due to clearance will be in proportion to the volume of the space and the press-

ure of the steam, all other things remaining constant. If, however, with inert walls, there is a complete compression,—*i. e.*, a compression up to initial pressure,—the result, so far as steam-consumption is concerned, is the same as if there was no clearance whatever.

If we assume the walls to possess any given degree of conductivity, we have, for the two cases of no compression and complete compression, in the first, the losses due to conductivity and to clearance, and, in the second, the gains due to compression opposed to the losses due to the walls.

It is this last condition which usually obtains in practice, and it is this case which Professor Boulvin examines most fully.

In so doing he maintains that Professor Dery has confused two things which should properly be kept distinct, and holds that the real cause of loss is found solely in the action of the cylinder walls. This loss exists, regardless of the existence or absence of compression, and the only way in which it can be reduced is by supplying heat from some other source. The other source may be that of compression of exhaust steam by the piston, the latter being actuated by pressure previously furnished by live steam; or it may be live steam itself, furnished directly from the boiler to a steam jacket surrounding the cylinder walls.

The true conclusion of the Liége experiments, therefore, as enunciated by Professor Boulvin, is not that compression is very wasteful, but that it is more wasteful than jacketing. To use the words of his own conclusion, "it is more economical to reheat the walls by live steam than by the work of compression, because this work, being derived through a cycle of low efficiency, involves a large expenditure of heat."

Professor Boulvin expresses his sincere admiration of the laborious and valuable experiments of his colleague, and an appreciation of their value and importance, and avows his only intention to be that of further elucidation of the deductions from them.

The Electrical Transmission of Energy.

In connection with the formulating of a law regulating the transmission of energy, the department of public works of France has furnished to the chamber of deputies a report upon the electrical transmission of energy, and the document, prepared by M. A. Blondel, is now published in the *Annales des Ponts et Chaussées*, forming an elaborate review of the whole subject.

Beginning with an estimate of the magnitude of the natural sources of power at our disposal other than the combustion of such fuel as may be available in the form of coal, wood, and petroleum, M. Blondel refers, in general, to the future possibilities of power-generation in the cases of the tides, the winds, and the waves, and gives some interesting data about water power. Thus, for instance, the Seine alone, at the various dams along its course, represents 25,000 h. p., and the total water power available in France has been estimated at 10,000,000 h. p. The total power of the Rhine at the falls of Schaffhausen represents 1,750,000 h. p., although but a small portion of this is at present utilized, and the total water power already harnessed and utilized in Switzerland exceeds 200,000 h. p. M. Blondel does not assume that water power is destined to supersede coal,—at least not for a long time,—and adds that electrical transmission appears likely to enable coal mines now unavailable to be worked by conversion of the fuel into power on the spot, in which case the cost of fuel transportation would be avoided by direct transmission of power.

A general discussion of the generation is given in the paper, showing the capabilities and limitations of the direct current, and also the especial features of polyphase alternating currents, together with the methods of transmitting and transforming them. The most extensive portion of the paper, however, is that which deals with the applications of electrical energy, and much valuable information is given concerning existing installations for industrial purposes.

Apart from lighting and tramway service, the growth in the electro-chemical

and electro-metallurgical industries is a most significant feature in connection with the commercial exploitation of the electric current. It is stated that upwards of one hundred and twenty-five tons of silver are electrically deposited every year, while the magnitude of the electrotyping industry has not been computed. The direct refinement of copper, the winning of aluminum, and the production of the carbides of calcium and silicon are industries which have been practically created by the development of electrical energy.

When we consider the transmission of motive power by various methods, it is evident that electricity is less wasteful than any other known agency. The efficiency of compressed air ranges from 35 to 55 per cent., the latter figure being reached only in the case of reheating, while for moderate distances electric transmission easily attains an efficiency of 80 per cent. The experience in Switzerland with teledynamic cables demonstrated a loss of 4 per cent. for every 100 metres, while with high-pressure water 60 per cent. is the maximum efficiency so far reached.

The general tendency to use electric transmission in machine shops is noted, and the advantages over belting and gearing are shown to be such as to make its growth certain and rapid. The use of electric elevators in business buildings and hotels, and of electric cranes and hoists in warehouses and commercial establishments, must also furnish a continually-widening field of applications.

In mining operations the convenience and safety of electricity both for power and lighting are considered, and numerous installations, in France, Belgium, and Germany, are noted.

In discussing the question of the long-distance transmission of power by electricity the commercial features receive the consideration which their importance demands. The cost of the line constitutes one of the most important questions, but sufficient data are given from existing installations to show that an economical transmission is possible within limits of 50 kilometres (about 30 miles) and, with high-tension alternating currents, probably much farther.

At the same time the fact is emphasised that the immediate future of electricity in the industrial arts depends largely upon the grouping of the industries about the source of power. Great cities have been built up heretofore because of proximity to harbors, fuel or mineral deposits, and lines of transportation, and proximity to natural sources of power will prove an equally potent factor in urban and industrial growth.

The electric current is simply a means enabling the power to be set to work, and, the less of it is wasted in transmission to a distance, the better. Transportation of the manufactured product is an easy matter, but power is best utilized near its source.

Motors for Blast-Furnace Gases.

MUCH has been said and written during the past few months about the use of blast-furnace gases in internal-combustion motors, and several working trials have been made, of which notice has been taken in these columns.

One feature of these experiments which has an important bearing upon the success of the idea is treated in a paper in *La Revue Technique*,—*viz.*, the modifications to be made in the motor in order to adapt it to the gases to be employed.

When it was first proposed, early in 1895, to use the furnace gas in a motor at Cockerill works at Seraing, in Belgium, the engineers of the establishment, MM. Bailey and Kraft, took a Simplex gas engine as arranged for use with producer gas, after assuring themselves that the gases discharged from the furnace were similar to the product of a gas producer. This engine, of 4 h. p., was started in December, 1895, and ran successfully for eighteen months, averaging sixteen hours per day.

Some experiments with this little engine showed that a modification in construction practically doubled its power, and, with the experience thus gained, plans were made for a new engine, to develop not less than 150 h. p. with furnace gas,

operating a François air-compressor. The designs for this machine were made by M. Delamare-Deboutteville, and executed at the works at Seraing, and it was started in a very satisfactory manner in April of this year, delivering 200 h. p. without difficulty, using the gas ordinarily furnished by the furnaces at Seraing.

The principal difficulties to be encountered in using furnace gas in a motor are the presence of dust and the tardiness of ignition. In this case the dust is successfully removed by passing the gas through three pairs of Korting scrubbers, these consisting of towers five feet in diameter and twenty feet high, filled with coke moistened with a water-spray. Ordinarily the gas proceeds directly from the scrubbers to the moter, being impelled by an exhauster operated by an electric motor, but it can be diverted to a gas-holder either for storage or measurement.

The engine itself is a heavily-built machine with single cylinder, operating on the usual Beau-de-Rochas cycle, the principal feature being that the compression is carried up to eight atmospheres, the ignition being by electric spark, and the governing being effected by varying the admission of air. The cylinder is 300 millimetres bore (11.8 inches) and 1 metre stroke (37.97 inches), and the engine makes 100 revolutions per minute. The fly-wheel is 4 metres (13 feet) in diameter and weighs 15 tons.

In considering the difficulties of operating engines with such gas as can be obtained from the ordinary blast furnace, the principal objection which has been raised is the presence of dust; and Herr Lürmann, in his discussion of the subject at the meeting of the Eisenhuttenleute (see ENGINEERING MAGAZINE, June, 1898, page 480), maintained that no process of scrubbing could so eliminate the dust as to permit the gas to be used without injury to the cylinder. As a matter of fact, the little 8-h. p. engine at Seraing ran satisfactorily for four months without the cylinder being opened, and, when examined, showed no signs of injury. There are few steam boilers which could be operated four months without cleaning.

Another objection which has been raised to furnace gas is the irregularity of composition, but at Seraing this difficulty was not encountered. On the contrary, frequent analyses of the gases showed the composition to be nearly uniform, and the calorific power, as determined by the Mahler bomb, varied only between 800 and 1,000 calories per cubic metre (90 to 112 B. T. U. per cubic foot).

The mechanical success of this 200-h. p. gas engine has been such that the results of economy-tests will be awaited with interest. The high compression appears to have removed any difficulty with regard to ignition, and the management at Seraing seems to have sufficient confidence in the system to announce the determination of proceeding to the construction of a motor, on similar lines, of 400 to 500 h. p., for operating a blowing engine for regular furnace blast.

Automobile Cabs.

ONE of the first practical uses to which the modern automotor was put was that of cab service in the city of Paris, not only because of the demand for such service, but also because the excellence of the pavements made the work easier for the vehicles than road-traveling.

In order to test the availability of the various automobiles in general use for city cab service, the Automobile Club organized a series of trials, which took place from June 1 to June 12 of this year, and which are described and discussed at length in several publications, among which we may mention *L'Electricien*, *Le Génie Civil*, and *La Revue Technique*.

Three routes were laid out through various portions of Paris, these being selected so as to afford the best possible tests as regards grades, narrow streets, and difficult conditions of travel.

Each of these routes represented 60 kilometres of travel (about 37 miles), and each vehicle was required to traverse each route three times. The power consumed was also tested by trial runs of 1,000 metres, both on a level and on the ascent from Suresnes to Mont Valerien,—the latter being a grade of more than 8 per cent.

Tests were also made of the ease of manœuvring and of the promptness with which the brake can be effectively applied under speed.

Twelve vehicles took part in the tests, of which eleven were propelled by electricity and one by petroleum. Illustrations and descriptions of the various cabs are given in *La Revue Technique*, enabling their general construction to be readily understood, although no working details are given.

The most notable departure exhibited by any of the vehicles from the ordinary type of automobile was that of the Jeantaud cab, in which the accumulators and motor were placed in a separate portion in front of the cab proper, the latter being therefore hauled by the motor section which practically takes the place of the horse. The operator is mounted above and behind on the cab, in the same manner as the driver of a hansom, and the motor section is so low and unobtrusive that the occupants have a clear view of the road before them.

This arrangement operated so satisfactorily as to gain the first prize of 1,000 francs, and it seems probable that a similar design for vehicles of other types would offer numerous commercial advantages.

Nearly all the other automobiles exhibited and tested resembled existing cabs, the absent horse being replaced by storage-batteries beneath or behind. The conservative manner in which the ideas of the carriage-builder were retained in minor details showed the reluctance of the constructors to avail themselves of the opportunities for originality at their disposal.

The Peugeot automobile, operated by a gasoline motor, excited the admiration of the jury and the spectators by the ease of its operation and the general handiness which it displayed, but the cost of the fuel, gasoline, which it employed placed it out of competition with the electrically-propelled vehicles, and prevented it from obtaining an award.

The trials were well sustained by nearly all of the vehicles entered, and the result showed that, for a city like Paris, where good pavements are the rule, but hilly sections, narrow streets, and some rough sections are also included, the automobile is well adapted for general cab service. One feature of the trials, however, must be noted,—namely, that the vehicles were in all cases operated by skilled drivers, these in many instances being the inventors or constructors themselves; equal ability could hardly be expected for this work in a general cab service. There is no reason to believe, however, that a greater capacity is required for a motor cab driver than for a motorman on an electric trolley, and this feature will hardly become an obstacle to the general introduction of automobiles.

Anti-Friction Alloys.

AMONG the various investigations conducted by the French Société d'Encouragement there is a series conducted by a special committee for the study of the properties of the various metallic alloys, and in a recent issue of the *Bulletin* of the society there is a report by M. G. Charpy upon the various white alloys commonly called anti-friction metals.

This subject possesses both a practical and a scientific interest, since such alloys are widely used in the arts, and the application of the recent methods of investigation into their physical constitution has revealed important facts concerning their properties.

In France the practical value of white-metal journal boxes for railway carriages was demonstrated by the experience of the Paris-Lyons-Mediterranean Railway, on which, after a number of years' trial, the report of the engineer, M. Chabal, stated not only that there were fewer cases of heating than with bronze boxes, but also that on heavy, slow trains there was a reduction of 20 per cent. in the frictional resistance.

The term "white metal" is rather indefinite, but is generally intended to include alloys soft enough to adapt themselves, to a greater or less degree, to the configuration of the journal; but M. Charpy gives tables of alloys of tin, copper, and antimony; of copper, tin, and zinc; and of miscellaneous composition; citing the authority, composition, and

service in a manner which enables the nature of the material under discussion to be identified very closely.

It might be supposed that a metal which could adapt itself under pressure to the form of the journal would be too soft to afford a suitable wearing resistance, and the conditions of plasticity and durability appear to be too contradictory to be embodied in the same material. The only way in which both properties can be obtained is to use an alloy consisting of hard particles embedded in a plastic alloy. This constitution is practically that which has been attained by empirical methods, as subsequent researches have verified.

Accepting these two properties as essential for a satisfactory bearing metal, it is evident that there must be two corresponding methods of test. The plasticity may be determined by suitable compression tests, and the compressibility should not be greater than is necessary for adaptation to the form of the journal; else there will be a continual yielding, which is most injurious. The compression tests also show the resistance to crushing,—a very essential quality.

The physical constitution is determined by a microscopical examination. The proper composition for an anti-friction metal is very clearly defined under the microscope, and by polishing the surface upon an elastic support the softer portion is worn away, leaving the hard particles in sufficient relief to give a well-defined texture even without the aid of etching. The resistance to wear during polishing also gives an indication of the hardness.

Adopting these methods, M. Charpy proceeds to examine a number of the more-generally-used alloys, beginning with the binary alloys, such as lead and antimony, and following with ternary alloys, as those of lead, tin, and bismuth, using in the latter cases the well-known triangular model of Thurston as a means of indicating the results to the eye.

One of the most interesting features of the subject is the relation between the relative fusibility of the constituents of an alloy and the corresponding physical properties, as revealed by the metallographical examination. By reproductions of numerous microphotographs the successive phases of solidification are shown, and the influence of the rates of cooling is clearly indicated by the variations in crystalline and molecular constitution.

The detailed results of this important investigation are too voluminous to be given here, and the reader must be referred to the original paper; but the general conclusions are of interest.

The desired constitution of a plastic material enclosing hard grains, M. Charpy asserts, can be obtained with binary alloys, the hard particles being composed of a simple metal, such as antimony, or of a composition of antimony and tin, antimony and copper, or tin and copper. It is generally preferable, however, to use ternary alloys, since the complex composition of the cementing portion renders it possible to obtain the desired qualities more readily and certainly. Especially valuable in this respect are the alloys of bismuth, lead, and tin, and the methods of investigation given in the paper of M. Charpy enable the characteristics of any such alloy to be obtained with a minimum number of trials, within the limits available for practical purposes.

The general physical constitution may be determined by micrographical examination, and a few compression tests will show whether the alloy is too hard or too soft. For the best results it should yield steadily and uniformly to increasing pressure, neither breaking into fragments or giving way too readily.

These tests having been made in the laboratory, the choice of the most available alloy for practical use will be controlled by commercial conditions, and there will be no need for empirical methods in any respect.

In addition to the investigations of the soft bearing metals, the paper gives the results of examinations of ternary alloys of copper, tin, and antimony; lead, tin, and antimony; copper, lead, and antimony; zinc, tin, and antimony; and copper, tin, and lead. These will be of much use for special purposes, and furnish valuable information not generally available.

Transportation at the Paris Exposition.

AT a recent meeting of the commission of the Paris exposition of 1900 having in charge the subject of electrical transportation of visitors within the exhibition grounds, a number of projects were examined and discussed, as reported in *La Revue Technique*. The great extent of the grounds, and the fact that there are several sites situated at considerable distances apart, render it especially desirable that the transportation facilities should be complete and of ample capacity, and hence the requirements were very carefully drawn by the commission. Five schemes were submitted, the French Thomson-Houston Company, the Decauville Company, the Electrical Company of the Left Bank at Paris, M. L. Francq, and M. de Mocomble being the competitors.

Each of the first three proposed the construction of a single-track electric railway of one metre gauge; the fourth proposed to construct a double-track railway; the fifth offered a single-track railway and a double-speed traveling platform.

Each bidder had a special financial scheme to submit. The Thomson-Houston Company was the only one demanding a subsidy, asking an advance of 1,500,000 francs, in return for which the exposition administration was to get the gross receipts from all passengers in excess of 9,000,000 and up to 15,000,000, and two-thirds of the receipts from all passengers in excess of 15,000,000.

The Decauville Company offered 50 per cent. of the net receipts, after all expenses had been deducted, and 5 per cent. additional of the same receipts for participating in the personnel of the exposition.

The Company of the Left Bank offered to allow the administration 20 per cent. of the gross receipts, and 25 per cent. of its net profits.

M. Francq proposed that the administration should pay all costs of installation above 3,500,000 francs, and offered to pay 1 centime per passenger if the number should exceed 15,000,000, 2 centimes if it should exceed 20,000,000, etc.

M. de Mocomble made the simplest proposition of all, standing ready to bear the costs of installation, and to pay 1 centime for every passenger carried, regardless of the number.

The proposed fares were as follows: Thomson-Houston and Decauville each proposed but one class, with a fare of 25 centimes; the Company of the Left Bank and M. Francq proposed two classes,—one at 50 centimes, and a second at 25 and 30 centimes; while M. de Mocomble planned to charge 25 centimes on the railway and 50 centimes on the traveling platform.

Single-track roads seemed hardly adequate to the immense traffic to be expected, and it was not so much the desire of the commission to make a profit upon the transportation as to be relieved from the management of the matter, and at the same time secure ample means of handling the greatest crowds. The double-track scheme of M. Francq contained a possibility of involving the administration in the completion of the construction, and the rates of fare proposed by him were higher than the maximum official scale.

The scheme of M. de Mocomble alone remained, and it received, therefore, careful consideration. If its operative success could be assured, there is no doubt that the traveling platform would offer a transporting capacity far greater than any railway system involving trains of cars; instead of 25,000 passengers per hour, it could readily handle 35,000 to 40,000.

The full details of the proposed structure have already been given in these columns (see ENGINEERING MAGAZINE, November, 1897, p. 317), and the manner in which the details have been worked out should convince any one of its practicability. The commission, however, has required that M. de Mocomble shall construct a small circular section of traveling platform according to his plans, and demonstrate within six months the entire feasibility of the system. In order to reimburse him for the expense of this preliminary construction, the administration is to waive its claim to any receipts until the number of passengers carried shall have reached 10,000,000,—this amounting to a sum of 100,000 francs, the estimated cost of the experiment.

THE ENGINEERING INDEX

INTRODUCTORY

This Index is issued separately from the Magazine printed on one side of the paper only, and is supplied to subscribers for THE ENGINEERING MAGAZINE at a nominal charge of fifty cents a year to cover cost. In this form it meets the exact requirements of those who desire to clip the items for card-index purposes.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed, in the original language, and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 15c. The letter A, B, or C denotes a price of 30 cts.; D, of 45 cts.; E, of 60 cts.; F, of 75 cts.; G, of 90 cts.; and H, of $1.35. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

Serial publications are indexed on the appearance of the first installment.

The titles and addresses of the journals regularly reviewed are given in full below, but only abbreviated titles are used in the Index. Other abbreviations employed are: Ill=Illustrated; W=Words; Anon=Anonymous.

To avoid the inconvenience of small remittances, and to cheapen the cost of articles to those who order frequently, we sell coupons at the following prices;—15c. each, or fifteen for $2, forty for $5, and one hundred for $12.

Each coupon will be received by us in payment for any 15-cent article catalogued in "The Engineering Index" of THE ENGINEERING MAGAZINE. For articles of a higher price, one of these coupons will be received for each 15 cents: thus, a 30-cent article will require two coupons; a 45-cent article, three coupons; and so on. With a supply of these coupons on hand no letter writing is required. Simply fill in the number of the article and your address, and mail the coupon to us.

This system is strongly commended to our readers. The coupons need only a trial to demonstrate their convenience.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

American Architect. *w.* Boston, Mass.
American Electrician. *m.* New York.
Am. Engineer and Railroad Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Geologist. *m.* Minneapolis, Minn.
American Journal of Science. *m.* New Haven, Conn.
American Journal of Sociology. *b-m.* Chicago, Ill.
American Machinist. *w.* New York.
Am. Manufacturer and Iron World. *w.* Pittsburg, Pa.
American Shipbuilder. *w.* New York.
Am. Soc. of Irrigation Engineers. *qr.* Denver, Col.
Annals of Am. Acad. of Pol. and Soc. Sci. *b-m.* Phila., Pa.
Annales des Ponts et Chaussées. *m.* Paris.
Architect. *w.* London.
Architectural Record. *q.* New York.
Architectural Review. *s-q.* Boston, Mass.
Architecture and Building. *w.* New York.
Architektonische Rundschau. *m.* Stuttgart.
Atlantic Monthly. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Automotor and Horseless Vehicle Journal. *m.* London
Bankers' Magazine. *m.* New York.
Bankers' Magazine. *m.* London.
Bankers' Magazine of Australia. *m.* Melbourne.
Berg- und Hüttenmännische Zeitung. *w.* Berlin.
Board of Trade Journal. *m.* London.
Boston Journal of Commerce. *w.* Boston, Mass.
Bradstreet's. *w.* New York.
Brick Builder. *m.* Boston, Mass.
British Architect. *w.* London.
Builder. *w.* London.
Bulletin Am. Iron and Steel Asso. *w.* Phila., Pa.
Bulletin of Bureau of Am Republics. *m.* Washington.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington, D. C.
Bulletin of the Univ. of Wisconsin, Madison, Wis.
California Architect. *m.* San Francisco, Cal.
Canadian Architect. *m.* Toronto, Ont.
Canadian Electrical News. *m.* Toronto, Ont.
Canadian Engineer. *m.* Montreal, P. Q.
Canadian Mining Review. *m.* Ottawa, Ont.
Century Magazine. *m.* New York.
Chautauquan. *m.* Meadville, Pa.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg, S. A. R.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington, D. C.
Contemporary Review. *m.* London.
Cosmopolitan. *m.* Irvington, N. Y.
Deutsche Bauzeitung. *b-w.* Berlin.
Dingler's Polytechnisches Journal. *w.* Stuttgart.
Domestic Engineering. *m.* Chicago, Ill.
Eclairage Electrique. *w.* Paris.
Electrical Engineer. *w.* London.
Electrical Engineer. *w.* New York
Electrical Engineering. *m.* Chicago, Ill.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electrical World. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Elektrochemische Rundschau. *b-m.* Frankfurt.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnisches Echo. *w.* Magdeburg.
Elektrotechniker. *b-m.* Vienna.

Elektrotechnischer Anzeiger. *s-w.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Engineer. *w.* London.
Engineer. *s-m.* New York.
Engineers' Gazette. *m.* London.
Engineering. *w.* London.
Engineering Assn. of the South. Nashville, Tenn.
Engineering and Mining Journal. *w.* New York
Engineering Journal. *s. an.* Stanford Univ., Cal.
Engineering Magazine. *m.* New York & London
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of the School of Prac. Sci. Toronto, Ont.
Eng. Soc. of Western Penn'a. *m.* Pittsburg, Pa.
Fire and Water. *w.* New York.
Forester. *m.* Washington, D. C.
Forum. *m.* New York.
Foundry. *m.* Detroit, Mich.
Gas Engineers' Mag. *m.* Birmingham, England.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Glasers Ann. f. Gewerbe & Bauwesen. *s-m.* Berlin.
Gunton's Magazine. *m.* New York.
Harper's Weekly. *w.* New York.
Heating and Ventilation. *m.* New York.
Ice and Refrigeration. *m.* New York.
Ill. Carpenter and Builder. *w.* London.
India Rubber World. *m.* New York.
Indian and Eastern Engineer. *w.* Calcutta.
Indian Engineering. *w.* Calcutta.
Industries and Iron. *w.* London.
Inland Architect. *m.* Chicago, Ill.
Iron Age. *w.* New York.
Iron and Coal Trades' Review. *w.* London.
Iron & Steel Trades' Journal. *w.* London.
Iron Trade Review. *w.* Cleveland.
Jour. Am. Soc. Naval Engineers. *qr.* Wash., D. C.
Journal Assn. Eng. Societies. *m.* Phila., Pa.
Journal of Electricity. *m.* San Francisco, Cal.
Journal Franklin Institute. *m.* Phila., Pa.
Journal of Gas Lighting. *w.* London.
Jour. N. E. Waterw. Assoc. *q* New London, Conn.
Journal Political Economy. *q.* Chicago, Ill.
Journal Royal Inst. of Brit. Arch. *s-q.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery. *b-m.* Fort Monroe, Va.
Journal Western Soc. of Eng. *b-m* Chicago, Ill.
Kansas University Quarterly. *qr.* Lawrence, Kan.
Locomotive. *m.* Hartford, Conn.
Locomotive Engineering. *m.* New York.
Locomotive Firemen's Mag. *m.* Peoria, Ill.
Machinery. *m.* London.
Machinery. *m.* New York.
Manufacturer's Record. *w.* Baltimore, Md.
Marine Engineer. *m.* London.
Marine Engineering. *m.* New York.
Master Steam Fitter. *m.* Chicago, Ill.
Mechanical World. *w.* London
McClure's Magazine. *m.* New York.
Metal Worker. *w.* New York.
Mines and Minerals. *m.* Scranton, Pa.
Mining and Sci. Press. *w.* San Francisco, Cal
Mining Journal. *w.* London.
Mining Reporter. *w.* Denver, Col.
Mitt. aus d. Kgl. Tech. Versuchsanst. Berlin.
Mittheilungen des Vereines für die Förderung des Local- und Strassenbahnwesens. *m.* Vienna.
Monatsschrift des Württ. Vereines für Baukunde. 10 parts yearly. Stuttgart.
Moniteur des Architectes. *m.* Paris.
Moniteur Industriel. *w.* Paris.
Municipal Affairs. *qr.* New York.
Municipal Engineering. *m.* Indianapolis, Ind.
National Builder. *m.* Chicago, Ill.
Nature. *w.* London.
Nature. *w.* Paris.
New Zealand Mines Record. *m.* Wellington, N.
Nineteenth Century. *m.* London.
North American Review. *m.* New York.
Oest. Monatsschr. f. d. Oeff. Baudienst. *m.* Vienn
Oest. Zeitschr. f. Berg- & Hüttenwesen. *w.* Vienna.
Physical Review. *b-m.* New York.
Plumber and Decorator. *m.* London
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Proceedings Engineer's Club. *q.* Phila., Pa.
Proceedings of Central Railway Club.
Pro. of Purdue Soc. of C. E. *yr.* La Fayette, Ind.
Progressive Age. *s-m.* New York.
Railroad Car Journal. *m.* New York.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago, Ill.
Railway Magazine. *m.* New York.
Railway Master Mechanic. *m.* Chicago, Ill.
Railway & Engineering Review. *w.* Chicago, Ill.
Railway World. *m.* London.
Review of Reviews. *m.* New York
Revue de Mécanique. *m.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines *m.* Liége.
Sanitarian. *m.* Brooklyn, N. Y.
Sanitary Plumber. *s-m.* New York
Sanitary Record. *m.* London.
School of Mines Quarterly. New York.
Schweizerisches Bauzeitung. *w.* Zurich.
Science. *w.* Lancaster, Pa.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York
Scientific Machinist. *s-m.* Cleveland, Ohio.
Scribner's Magazine. *m.* New York.
Seaboard. *w.* New York.
Sibley Journal of Eng. *m.* Ithaca, N. Y.
Southern Architect. *m.* Atlanta, Ga.
Stahl und Eisen. *s-m.* Dusseldorf.
State's Duty. *m.* St. Louis, Mo.
Steamship. *m.* Leith, Scotland.
Stevens' Indicator. *qr.* Hoboken, N. J.
Stone. *m.* Chicago, Ill.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago, Ill
Technology Quarterly. Boston, Mass.
Technograph. *yr.* Champaign, Ill.
Trans. Assn. C. E. of Cornell Univ. Ithaca, N. Y.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Civil Engineers. *m.* New York
Trans. Am. Soc. of Heat. & Ven. Engrs. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Transport. *w.* London.
Western Electrician. *w.* Chicago, Ill
Western Railway Club, Pro. Chicago, Ill.
Wiener Bauindustrie Zeitung. *w.* Vienna.
Wisconsin Engineer. *qr.* Madison, Wis.
Yale Scientific Monthly. *m.* New Haven, Conn.
Year Book of Soc. of Engs. Univ. of Minn.
Zeitschrift für Lokomotivführer. *m.* Hannover.
Zeitschrift f. Maschinenbau & Schlosserei. *m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ingen. *w.* Berlin.
Zeitschrift für Elektrochemie. *s-m.* Halle a. S.
Zeitschrift für Elektrotechnik. *s-m.* Halle a. S.

ARCHITECTURE AND BUILDING.

CONSTRUCTION AND DESIGN.

Cathedral.

Peterborough Cathedral. Description of the interesting fan vaulting of this cathedral, by the late Prof. Willis. Extract from his essay on the "Construction of the Vaults of the Middle Ages." Ill. 4000 w. Arch, Lond—July 8, 1898. No. 21528 A.

Dome.

The Steel Dome for the Yerkes Observatory, Lake Geneva, Wis. Illustrated description of the features of particular interest to engineers, the chief being the main dome and its operating machinery. 2800 w. Eng News—July 14, 1898. No. 21486.

Dome Construction.

Notes on the Theory of Dome and Tower Construction. (Beitrag zur Theorie der Kuppel- und Turm-Dacher.) R. Kohfahl. Discussing especially the details of framed structural metal domes, spires and towers, both from a theoretical and practical standpoint. Two articles. 9000 w. Zeitschr d Ver Deutscher Ing—June 25, July 2, 1898. No. 21736 each D.

Fire Regulations.

See Municipal Engineering, Miscellany.

Foundations.

Reconstruction of a Chicago Building Substructure. Illustrated description of method of underpinning a heavy 80 x 100-ft. building to put in a sub-basement, The Equitable Building. 1000 w. Eng Rec—July 9, 1898. No. 21421.

The Ivins Building, New York. Illustrated description of foundations and metal work in a 424-ft. building, the highest yet constructed. 3000 w. Eng Rec—July 16, 1898. No. 21507.

Tall Building.

Park Row Building, New York. Brief description with illustrations. 1400 w. Engng—July 8, 1898. No. 21541 A.

Theatre.

The Olympian Theatre of Palladio at Vicenza. Extract from a work by Albert A. Hopkins. Illustrates and describes the oldest permanent theatre in Europe, built since the time of the Romans. 1300 w. Sci Am—July 16, 1898. No. 21475.

HEATING AND VENTILATION.

Factories.

Ventilation of Textile Factories. W. H. Casmey. Read before the Yorkshire Dyers' and Colourists' Assn. Part first is largely arguments showing the necessity of fresh air both from a commercial and sanitary point of view. 2500 w. Prac Engr—July 8, 1898. Serial. 1st part. No. 21540 A.

Hot-Air.

An Interesting Furnace Heating System. Describes a system which successfully overcomes serious difficulties, designed by William G. Barrows, of Utica, N. Y. Ill. 1000 w. Met Work—July 16, 1898. No. 21494.

Mills House, No. 1.

Heating, Ventilating, and Sanitary Equipment of a Modern Hotel. C. Wadsworth, Jr. Read at Atlantic City meeting of the Am. Soc. of Heat. & Ven. Engs. Illustrated description of this New York hotel, designed for the accommodation of men who receive low wages. 6000 w. Engr, N. Y.—July 15, 1898. No. 21509.

Post-Office.

The Heating of a Small Post-Office Building. Describes and illustrates an unusual, though simple, system of ventilation and heating. 600 w. Eng Rec—July 16, 1898. No. 21508.

Public Institutions.

The Heating and Sanitation of Public Institutions. W. N. Twelvetrees. A very completely illustrated account of the heating and household arrangements at Brook Hospital near London. 4500 w. Engineering Magazine—August, 1898. No. 21795 B.

Radiators.

A Suggestion for Determining the Heating Surface of Indirect Radiators. H. Eisert. Read at Atlantic City meeting of the Am. Soc. of Heat. & Ven. Engs. Showing that the relative value of a heating surface depends mainly on the arrangement of the surface and its condition, and gives the results obtained by careful study. 2200 w. Heat & Ven—July 15, 1898. No. 21642.

Sanitation.

House Sanitation. Esther A. Pownal. Read at meeting of New Hope Farmers' Inst., Doylestown, Penna. Discusses the heating, lighting and ventilating of a house. 2800 w. San—July, 1898. No. 21351 D.

Ventilation Tests.

Some Accepted Tests of Ventilation—Are They Reliable? T. C. Northcott. Read at the Atlantic City, N. J., meeting of the Am. Soc. of Heat. & Ven. Engs. Discusses the tests for carbonic acid gas, the lime water test, and the anemometer. 1800 w. Met Work—July 23, 1898. No. 21601.

PLUMBING AND GASFITTING.

Cologne, Germany.

Sanitary Experiments at Cologne, Germany. W. M. Watson. Comments on the report of valuable experiments made to thoroughly investigate the whole system of plumbing, and the lessons to be learned from them. 1800 w. Can Engr—July, 1898. No. 21568.

Office Building.

Plumbing Details in the Ivins Building, New York City. Illustrates the general water-supply system and the soil and vent pipes of a very high building. 1300 w. Eng Rec—July 23, 1898. Serial. 1st part. No. 21616.

Pipe Joints.

English Views on Joint Making. W. J.

Maguire. Condensed from Manchester Health Lectures. Gives the practice in making joints connecting lead and iron pipe, and connecting branches with soil pipe. 900 w. San Plumb—July 1, 1898. No 21378.

Regulations.

Plumbing Regulations in Savannah, Ga. A copy of the ordinance in force in this city. 2200 w. San Plumb—July 1, 1898. No. 21379.

MISCELLANY.

Fireproof.

A New Type of Fireproof Construction. (Un Nouveau Type de Constructions Incombustibles.) Describing the use of expanded metal and cement to form a satisfactory system of fireproof construction. 1200 w. La Revue Technique—June 25, 1898. No. 21700 D.

Glasgow.

The Architecture of Our Large Provincial Towns. Considers the architecture of Glasgow in detail, giving many illustrations and general information. 6400 w. Builder—July 9, 1898. No. 21532 A.

Jubilee.

The Jubilee Exhibition at Vienna, 1898. (Jubiläums-Ausstellung 1898 in Wien.) A general plan of the grounds, together with elevation and plan of the pavilion of the three principal commissions. 1800 w. 1 plate. Oesterr Monatschr f d Oeffent Baudienst—July, 1898. No. 21748 D.

Landscape Architecture.

Landscape Phase of the University of California Plan. Warren H. Manning. Reviews the conditions and requirements of interest to those who have entered the competition for the architectural plan of this university. 2800 w. Am Arch—July 16, 1898. No. 21513.

The Metropolitan Reservations of Boston. Review of the report of Charles Eliot on the treatment of vegetation for scenic effects. 1000 w. Eng Rec—July 16, 1898. No. 21501.

Mortar.

Quality of Mortar. Gives some facts relating to mortar and its use, and the superiority of machine mixed mortar. 1500 w. Br Build—July, 1898. No. 21670 C.

Parks.

Architectural Features of the Boston Parks. Sylvester Baxter. Part first describes the bridge architecture of these parks, which is highly praised. 2200 w. Am Arch—July 16, 1898. Serial. 1st part. No. 21512.

CIVIL ENGINEERING.

BRIDGES.

Abutments.

Concrete Abutments for a Railroad Bridge at Buffalo, N. Y. Describes the interesting features in the rebuilding of the abutments of a bridge of the N. Y. C. R. R. made necessary by the deepening of the Erie Canal. Ill. 1100 w. Eng News—July 21, 1898. No. 21593.

Africa.

An American Bridge for South Africa. Illustrates a bridge recently shipped by an American firm, for the Orange Free State railways. 400 w. R R Gaz—July 29, 1898. No. 21690.

Aqueduct Bridge.

A Steel Aqueduct Bridge. Illustrated explanation of the details of a bridge with an aqueduct 96-ft. long, 53-ft. wide, and 9¾-ft. deep, on the Erie Canal. 800 w. Eng Rec—July 9, 1898. No. 21416.

Arch Truss.

The Surprise Creek Arch. Illustrated description of the design and erection of a 290-ft. pin-connected arch bridge on the Canadian Pacific railway. 1000 w. Eng Rec—July 16, 1898. No. 21503.

Criticism.

A Bridge that Ought to be Better. Illustration and criticism of bridge recently erected across the Cedar River, near Iowa City, Ia. Gives criticisms of J. A. L. Waddell with further explanations. 1400 w. Eng News—June 30, 1898. No. 21249.

Erection.

Bridge Erection by Projection in France. An explanation of the work. 600 w. Eng Rec—July 16, 1898. No. 21506.

Erection of the Newport and Cincinnati Bridge. Illustrated description of the construction and removal of two sets of false work over nearly 1500-ft. of waterway, the removal of old spans, the erection of two sets of new spans, and the corresponding work on the long approaches of an unusually wide, heavy bridge. 2400 w. Eng Rec—July 23, 1898. No. 21613.

Failure.

Fatal Collapse of a Highway Bridge. Illustrated description of an accident at Shelby, O., on July 4, 1898. 700 w. Eng Rec—July 23, 1898. No. 21614.

Suspension Bridge.

A Historic Bridge. Illustrated description of the first large cantilever trussed bridge, and the manner of erecting it across the Kentucky River. 1200 w. Eng Rec—July 9, 1898. No. 21415.

Swing Bridge.

A Recent Example of Automatic, Interlocking Machinery for Operating a Swing Bridge. Charles H. Wright. Illustrated description of devices used on a long span constructed by the Edge Moor Bridge Works, and their action. 800 w. Eng News—July 7, 1898. No. 21385.

Some Novelties in Swing Bridge Construction on the Trent Valley Canal. R. B. Woodworth. Illustrates and describes peculiarities of constructfon in two bridges crossing the Trent Valley Canal, Canada. 900 w. Eng News—June 30, 1898. No. 21250.

Viaduct.

The Müngsten Viaduct. (Le Viaduc de

Müngsten.) An illustrated account of this great steel arch, with views of the structure both in course of erection and when completed. 4000 w. 1 plate. Le Génie Civil—July 2, 1898. No. 21714 D.

CANALS, RIVERS AND HARBORS.

Anchors.

A Novel Fixed Anchor Construction for Jetties, Buoys and Light Ships. Illustrates and describes the very efficient system of anchors employed in the construction of a small jetty built at Atlantic City, N. J., in 1897. 800 w. Eng News—July 7, 1898. No. 21389.

Aqueduct Bridge.

See Civil Engineering, Bridges.

Canal Lift.

The Inclined Plane, as a Canal Lift. (Die Schiefe Ebene als Schiffs-Hebewerk.) Victor Schönbach. A discussion of the inclined plane system as a substitute for canal locks, showing the conditions under which it is mechanically and commercially applicable. Describes an improved form. Two articles. 8000 w. Zeitschr d Oesterr Ing u Arch Ver—June 17, 24, 1898. No. 21730 each B.

Dam.

The New U. S. Government Needle Dam at Louisa, Ky., on the Big Sandy River. Illustrates and describes the construction and operation. 5400 w. Engng News—July 7, 1898. No. 21384.

Docks.

Penarth Docks. Illustrates and describes a clever piece of engineering in connection with the entrance to these docks. 1800 w. Engng —July 15, 1898. No. 21633 A.

Dredging.

River and Harbor Dredging. Illustrated description of the sand dredger "Brancker" which was used for the removal of the Mersey Bar. 2400 w. Ind & East Engr—June, 1898. No. 21524 D.

Floating Dock.

See Marine Engineering.

Floods.

The High Water Catastrophes of 1897 in Austria. (Die Hochwasser-Katastrophe des Jahres 1897 in Oesterreich.) With graphical diagrams showing the drainage areas and rise in the rivers, compared with the rainfall. A valuable study in river hydraulics. 3500 w. 1 plate. Oesterr Monatschr f d Oeffent Baudienst—July, 1898. No. 21749 D.

Gauging.

Gauging of Streams. William G. Price. A description of some of the methods of velocity measurements used by the writer, including the use of the current meter and the rod float. Discussion. 6500 w. Jour W Soc of Engs—June, 1898. No. 21437 D.

Inter-Oceanic Canal.

An Inter-Oceanic Canal. Presents the need of such a canal in view of recent changes,—the annexation of the Sandwich Islands, &c. Discusses routes suggested, and the difficulties in the way. 1500 w. Bankers' Mag, N. Y.—July, 1898. No. 21443 D.

Jetty.

Jetty Construction on the Pacific Coast. Gwynn A. Lyell. A fully illustrated account of the construction of the successful jetty at the mouth of the Columbia river. 3000 w. Engineering Magazine—August, 1898. No. 21792 B.

Lighthouse.

The Electric Lighthouse at Ryvingen, Norway. (Le Phare Electrique de Ryvingen, Norvège.) Ch. Delgobe. An illustrated account of this fine new work, with plate showing the arrangement of the lantern and the production of the flashes. 3500 w. 1 plate. Le Génie Civil—June 18, 1898. No. 21711 D.

N. Y. Canals.

The New York State Canal Investigation. A full and interesting account of the project to improve the canals, the estimates given, the results of the careful investigation of the Commission appointed by the Governor, &c. 4800 w. R R Gaz—July 29, 1898. No. 21688.

Nicaragua.

The Nicaragua Canal. Urging the importance of this work and quoting from the paper by Alfred Noble, published in the *Journal of the Western Society of Engineers*. 2700 w. Gunton's Mag—July, 1898. No. 21293 C.

The Nicaragua Canal in its Commercial and Military Aspects. Joseph Nimmo, Jr. An argument against the construction of the canal showing the objections and difficulties in which the project is involved. 3000 w. Engineering Magazine—August, 1898. No. 21791 B.

Obstructions.

Obstructive Bridges and Docks in the Chicago River. G. A. M. Liljencrantz. Notes on the various obstructions to navigation found in the Chicago River, considering it as it is, as it will be, and as it might be. Illustrated by sketches. Discussion and correspondence. 11300 w. Jour W Soc of Engs—June, 1898. No 21-439 D.

Riparian Rights.

Two Recent Decisions Concerning Riparian Rights. Review of decisions in supreme ccurts of Maryland and New York upholding riparian owners' rights. 1400 w. Eng Rec—July 9, 1898. No. 21420.

Ship Canal.

New Ship Canal Entrance to the Harbor of Duluth, Minn. Improvements demanded by increased size of lake vessels and growth of lake commerce are now in progress. Illustrated description showing location and general dimensions of the old and new piers. 1800 w. Eng News—July 28, 1898. No. 21694.

Venice.

The Lagoons of Venice. Giacomo Boni. Discusses the scheme for modernizing Venice, and urging all who have influence to use it in defending her lagoons. Ill. 2500 w. Jour Roy Inst of Brit Arch'ts—June 11, 1898. No. 21383 B.

Water Flow.

A New Formula by Bazin for Computing Flow of Water in Open Channels. Brief explanation of the formula and the reason for deducing it. 900 w. Eng News—July 14, 1898. No. 21490.

IRRIGATION.

Artesian.

Artesian Irrigation. The method of irrigation used in South Dakota, where the supply is obtained from artesian wells, is described. 1100 w. Sci Am—July 23, 1898. No. 21587.

Wells.

Wells and Irrigation. Discussing the sinking of wells in India for irrigation and domestic use, giving arguments advanced in favor of the project, and also the harm liable to follow unless their use and repairs are controlled. 1200 w. Ind Engng—June 25, 1898. No. 21685 D.

MISCELLANY.

Cement.

Annual Meeting of the Association of German Portland Cement Manufacturers. Abstracted by S. B. Newberry from the Official Report. 2500 w. Eng News—July 7, 1898. No. 21387.

Comparison of Recent Specifications for Fineness and Tensile Strength of Cements. Requirements in specifications for cement, with editorial. 2000 w. Eng News—July 28, 1898. No. 21698.

The Distinction between Slag and Portland Cements. Presents the unfortunate results of selling slag as Portland cements. 1800 w. Eng Rec—July 9, 1898. No. 21417.

The Empire Portland-Cement Plant at Warners, N. Y. Frederick H. Lewis. Illustrated description of a large plant running on the semi-humid process. 1600 w. Eng Rec—July 16, 1898. No. 21502.

The Portland Cement Industry of the World. Bernard L. Green. Reviews the past and present state of the industry in each of the cement-producing countries. Discussion. 10000 w. Jour of Assn of Engng Soc's—June, 1898. No. 21499 C.

Commercial Engineering.

Commercial Aspect of Engineering. Charles E. Larrard. Extracts from a paper read before the South West London Polytechnic Engineering Society. Part first discusses the need of attention in technical instruction to the preparation of estimates and commercial management. 3800 w. Prac Engr—July 8, 1898. Serial. 1st part. No. 21539 A.

Engineering.

A Year's Progress in Engineering. Alphonse Fteley. Slightly condensed from his address at the Detroit meeting of the Am. Soc. of Civ. Engs. Interesting review of railway construction and operation, canals, harbors, water supplies, buildings, tunnel construction, &c. 6800 w. Eng News—July 28, 1898. No. 21699.

Forestry.

Forestry in Relation to Physical Geography and Engineering. John Gifford. Considers the benefits derived from the forests, other than the value of the wood, and urges the importance of legislation for their protection. Ill. 6000 w. Jour Fr Inst—July, 1898. No. 21298 D.

Hawaii.

Engineering Work in the Hawaiian Islands. Describes the construction of the Nuuanu Pali road, up a steep mountain side, and mentions other engineering work. Ill. 900 w. Eng News—June 30, 1898. No. 21254.

Hydraulics.

Two Graphic Methods Applied to Hydraulic Calculations. Ponsonby Moore Crosthwaite. A comparison of the two methods of plotting diagrams, with an explanation of the principle and the advantages. 1400 w. Engng—July 15, 1898. No. 21632 A.

Italy.

Engineering in Italy. Ettore de Castro. General remarks with an illustrated description of the heating and ventilating plant in the largest hospital in the world—the Policlinic Umberto I°, in Rome. 2500 w. Power—July, 1898. No. 21364.

Paint Tests.

Tests of Various Paints on the 155th St. Viaduct, New York City. Presents the report of Henry B. Seaman upon the condition of the various paints applied as a preliminary test before repainting the structure. 1000 w. Eng News—July 7, 1898. No. 21388.

Surveying.

Co-ordinate Survey of the City of Boston. Frank O. Whitney. Describes the work of the Board of Survey appointed to devise a scheme of streets for the entire city, as a basis for future street improvements. 8500 w. Jour of Assn of Engng Soc's—June, 1898. No. 21498 C.

Measuring Apparatus, Kings County Survey, N. Y. Samuel McElroy. Describes methods and apparatus used in making this survey. Discussion. 4500 w. Jour W Soc of Engs—June, 1898. No. 21440 D.

Timber Testing.

Progress in Government Timber Testing. From the annual circular (No. 18) of the forestry division of the department of agriculture, on the investigations made during 1897. Gives briefly the most important conclusions reached, with editorial. 3800 w. Ry & Engng Rev—July 2, 1898. No. 21353.

Progress in Timber Physics. A valuable report of the Division of Forestry of the U. S. Department of Agriculture, giving the results of timber tests, including data about the influence of size of test specimens, and of the distribution of moisture. 15000 w. U. S. Dept of Agriculture, Circular No. 18—January 2, 1898. No. 21776 B.

Relation of Compression Endwise Strength to Breaking Load of Beam. S. T. Neely. From Circular No. 18, Division of Forestry, U. S. Dept. of Agriculture. Data, diagrams and tables, giving information obtained by tests. 2400 w. Ry & Engng Rev—July 9, 1898. No. 21435.

ECONOMICS AND INDUSTRY.

COMMERCE AND TRADE.

Cotton Spinning.

Profits on Cotton Spinning in Japan and China. A statement of the conditions of this industry which is likely to come into competition with British products. 1500 w. Engng—July 1, 1898. No. 21465 A.

The Cotton Manufacturing Industry in Mexico. Editorial review of this industry in Mexico, and its recent rapid development, showing that the conditions render it very hard for English cottons to compete with them. 2000 w. Engng—July 15, 1898. No. 21636 A.

The Progress of the Cotton Industry in Japan and China. Discussing points relating to progress being made in this industry. 2000 w. Ind & East Engr—June, 1898. No. 21523 D.

Dangers.

Industrial Dangers in England. Calls attention to the changed conditions and the dangers arising from the dissatisfaction of the laboring class. Thinks England is coming to need protection against continental Europe to maintain the wage level. 2500 w. Gunton's Mag—July, 1898. No. 21292 C.

Hawaii.

The Hawaiian Islands. Brief report of their commerce, giving comparative tables of importations for 1896 and 7. 500 w. Bos Jour of Com—July 23, 1898. No. 21606.

Interstate Commerce.

See Railway Affairs, Legal.

Philippines.

Facts about the Philippines. Frank A. Venderlip. Treats of their importance as a base for commercial operations, their products, mineral resources, &c. Ill. 5200 w. Century Mag—Aug., 1898 No. 21683 D.

The Philippine Islands. Frank F. Hilder. An outline sketch of these islands, noting their commercial advantages, natural resources, and their value to the United States. 5500 w. Forum—July, 1898. No. 21294 D.

The Philippine Islands. John A. Osborne. An account of these islands, describing their characteristics, inhabitants, and the value of their products. 2300 w. Chau—July, 1898. No. 21289 C.

Prices.

Comparative Prices of 107 Staple Articles, Raw and Manufactured Products, Produce, Cattle and Meats. Tabulated report with comments on the movement of prices. 3500 w. Bradstreet's—July 9, 1898. No. 21400.

Recent Movement of Prices of Iron Ores, Iron and Steel in Different Countries. Reports output and prices in the most important countries regarding iron-ore, pig iron, and finished iron and steel. 2200 w. Ir & Coal Trds Rev—June 24, 1898. No. 21333 A.

Rubber Prices.

The Latest Action Regarding Prices. Information concerning the advance in prices of mechanical goods due to the high price of crude rubber. 1500 w. Ind Rub Wld—Aug. 1, 1898. No. 21801 D.

Some Real Needs of the Rubber Trade. Letter from a manufacturer pointing out some of the difficulties met in regulating prices so as to permit reasonable profits. 1300 w. Ind Rub Wld—Aug. 1, 1898. No. 21802 D.

Rubber Trade-Marks.

Trade-Marks for Mechanical Rubber Goods. List of over 500 trade marks with the firm names. Ind Rub Wld—Aug. 1, 1898. No. 21803 D.

San Jose Scale.

International Relations Disturbed by an Insect. L. O. Howard. On the embargo against American plants and fruits. 2100 w. Forum—July, 1898. No. 21205 D.

Spain.

The Resources and Industries of Spain. Edward D. Jones. Reviews the characteristics of the chief industrial districts of Spain showing their diverse character; the undeveloped state of the commerce; and the many needs of the nation if it is to keep pace with the progress of the world. 3000 w. N Am Rev—July, 1898. No. 21290 D.

United Kingdom.

The Trade and Industries of the United Kingdom in Their Relations to Those of Other Countries. Extracts from a report which the Statistical Department of the Swedish Administration has this year issued on the trade and industries of Great Britain and Ireland in their relation to those of foreign countries, showing that their position continues to compare favorably with any other nation. 2500 w. Col Guard—July 8, 1898. No. 21552 A.

United States.

America Revisited in War Time. Henry Norman. An article very complimentary to the American people, recognizing their mechanical ingenuity and commercial enterprise, and discussing the new conditions likely to arise from the war with Spain. Urges the alliance with England, as advantageous to both nations, and for the advancement of civilization. 4000 w. McClure's Mag—July, 1898. No. 21276.

A Most Remarkable Year's Commerce. Editorial comment on the recently completed record by the Bureau of Statistics, which shows the exports to be twice as great as the imports. 900 w. Bos Jour of Com—July 23, 1898. No. 21605.

Trade Details of a Remarkable Year. Editorial on the record of the foreign trade of the United States in 1897-98. 1000 w. Bradstreet's—July 23, 1898. No 21607.

CURRENCY AND FINANCE.

Coins.

Values of Foreign Coins and Currencies. Statement covering from Jan. 1, 1874 to April 1, 1898. 1200 w. Cons Repts—June, 1898. No. 21240 D.

Gold Circulation.

Increasing the Circulation of Gold. Alexander

E. Outerbridge, Jr. Urging the circulation of gold among the people, by the issuing of gold coins of denominations suitable for distribution in payment of debts of moderate amounts. 1500 w. Bankers' Mag—July, 1898. No. 21444 D.

GOVERNMENTAL CONTROL.

Eight-Hours' Law.

The United States Supreme Court and the Utah Eight-Hours' Law. Florence Kelley. Reviews the legislation on this subject in various states, and the opinions advanced, and points the importance and lessons of this decision. 5000 w. Am Jour of Soc—July, 1898. No. 21423 D.

LABOR.

Compensation Act.

The Results of a Private Workmen's Compensation Scheme. Particulars given by Mr. George Livesy, regarding the working of his scheme, with editorial. 3000 w. Engr, Lond —June 24, 1898. No. 21328 A.

The Workmen's Compensation Act, 1897. C. S. Ellery. Read at Belfast meeting of the Incorporated Gas Inst. Discusses the liability of the gas industry and how best to meet the claims. Statistical tables of accidents in gas works which seem to indicate that about 3s. per £100 of wages ought to meet the requirements of the act. Discussion. 5600 w. Gas Wld—June 25, 1898. No. 21345 A.

Cost of Labor.

The Cost of Boiler-Room Labor. Extracts from a circular issued by the Mutual Boiler Insurance Co. of Boston, Mass., with remarks. 900 w. Eng News—July 28, 1898. No. 21695.

Machinery.

Does Machinery Displace Labor? C. Wood Davis. Discusses the official statements of Carroll D. Wright, and the effect of machinery on labor, thinking the question worthy of serious consideration. 6500 w. Forum—July, 1898. No. 21297 D.

Relief Organizations.

Brotherhood Relief and Insurance of Railway Employees. Emory R. Johnson. Considers the relief and insurance organizations; the brotherhoods, their plan and organization; the benefit departments, ladies' auxiliaries; the policy and probable future of the work. 17500 w. Bul of Dept of Labor—July, 1898. No. 21619 D.

Statistics.

Contemporary Labor. (Le Travail Contemporain.) Col. Fix. A comparison of labor statistics, in various parts of Europe, in connection with the development of various lines of industry. Serial. 1st part. 3000 w. La Revue Technique—June 25, 1898. No. 21705 D.

Steel Trade.

Conciliation in the Steel Trade. Editorial giving particulars concerning the methods used by the Board of Conciliation and Arbitration for the Manufactured Steel Trade of the West of Scotland. 1000 w. Engng—June, 24, 1898. No. 21324 A.

MISCELLANY.

Baths.

Public Baths. (Volksbäder.) A general account of the various kinds of public baths, and a plea for their wider introduction in Germany. The providing of baths is held to be as much of a public duty as that of general water supply. 3500 w. Gesundheits-Ingenieur—June 30, 1898. No. 21743 B.

Cotton Industry.

Effect of the Cotton Spinning Industry in China upon the Kindred Industry in India. Walter C. Wood. A comparsion of the basis upon which this industry is conducted in both countries; also comparing climates, mills, machinery, people, &c. 4800 w. Jour Soc of Arts —June 24, 1898. No. 21339 A.

The Depression in the Cotton Industry: A Remedy. Luther F. McKinney. Considers the depression of the cotton industry to be due to over production, and that the remedy is a wider market. Thinks a large share of the trade of South America should be secured and suggests means. 2400 w. Forum—July, 1898. No. 21296 D.

Cuba.

Cuba's Wealth to be Expanded. Bradley T. Johnson. Opportunities for enterprise when the island is under stable government. 1800 w. Mfrs Rec—July 8, 1898. No. 21390.

Exposition.

Universal Exposition of 1900. (Exposition Universelle de 1900.) A review of the present condition of affairs, including the various systems proposed for the transportation of visitors within the exposition grounds. 4000 w. La Revue Technique—June 25, 1898. No. 21703 D.

ELECTRICAL ENGINEERING.

ELECTRO-CHEMISTRY.

Electrical Industries.

The Electrical Industries of Sault Ste. Marie. F. H. Clerque. Abstract of an address delivered before the Northwestern Elec. Assn. Most of the industries considered are electro-metallurgical processes. 1800. Elec Wld—July 2, 1898. No. 21363.

Electrolysis.

The Carlin Tube. A. von Dessauer. Describes a new connection for anodes and cathodes and states the advantages. 1500 w. Jour of Chem & Met Soc of S Africa—May, 1898. No. 21656 E.

Electroplating.

Electroplating on Wood. C. F. Burgess. Describes a process by means of which a metallic surface on wood and other non-conducting materials has been obtained. 2000 w. Elec Wld—July 30, 1898. No. 21673.

Polarization.

A Simple Method for the Determination of Polarization. (Eine Einfache Methode zur Bestimmung der Polarisation.) Dr. Heim. Describing a method which involves the comparison of results obtained by measuring the voltage with two and with three electrode plates; the subject is discussed at length and practical examples given. 3500 w. Zeitschr f Elektrochemie—June 5, 1898. No. 21767 H.

Refining.

Some Notes on the Electrolytic Refining of Tin and the Recovery of Tin from Its Ores. Sherard Cowper-Coles. Describes methods which have been tried, and the results obtained. 900 w. Elec Engr, Lond—July 15, 1898. No. 21650 A.

See Mining and Metallurgy, Copper.

LIGHTING.

Arc.

The Electric Arc. (Ueber den Elektrischen Lichtbogen.) W. Mathiesen. A general account of the electric arc considered independently of any especial lamp mechanism, including the use of electrodes of various materials. 2500 w. Die Elektrizität—June 11, 1898. No. 21768 B.

Arc Lighting.

A Few Interesting Pointers Concerning Enclosed Arc Lighting. J. H. Hallberg. Notes causes of trouble and calls attention to the advantage of having the men who sell, install, and care for these lamps more familiar with the mechanical and electrical details. 2800 w. Elec Eng, N. Y.—July 14, 1898. No. 21445.

Central Station.

A Modern Electric Central Station. George A. Damon. Illustrated detailed description of the plant of the Imperial Electric Light, Heat and Power Company, of St. Louis, Missouri, given as showing the latest solution of the problem of the generation and distribution of electrical energy. 5000 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21287 D.

How to Overcome Some of the Difficulties Encountered by Central Station Men. A. A. Wright. Read at meeting of Can. Elec. Assn. Deals with street lighting, commercial lights, incandescent service, meters, &c. Discussion. 2500 w. Can Elec News—July, 1898. No. 21561.

The Edison Central Station at Paris, France. L. Bayly. Brief detailed description. 1000 w. Elec Rev, N. Y.—July 6, 1898. No. 21381.

Distributing Systems.

Two-Wire Distributing Systems and Lamps, 200-240 volts. John W. Howell. Presents the advantages over the three-wire system, and discusses the system in detail. 2300 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21278 D.

Edinburgh.

The Electric Lighting of Edinburgh. Frank A. Newington. Read at meeting of the Incorporated Assn. of Munic. and County Engrs. Detailed description. 2300 w. Elec Eng, Lond—July 8, 1898. No. 21535 A.

Exposition.

The Lighting of the Trans-Mississippi Exposition. Illustrates and describes the extensive electrical illumination. 800 w. Elec Wld—July 9, 1898. No. 21401.

The Trans-Mississippi and International Exposition. An illustrated account of some of the electrical features of the Omaha fair, and the effects of the illumination. 1800 w. Elec Rev, N. Y.—July 20, 1898. No. 21569.

Glasgow.

The Glasgow, Scotland, Municipal Lighting Plant, Port Dundas. Illustrates and describes a plant which will contain a great deal of American apparatus. 800 w. Elec Eng, N. Y.—July 21, 1898. No. 21573.

High Pressure.

Installations for Operation at a Pressure of 250 Volts. (Ueber Installationen für eine Gebrauchsspannung von 250 volt.) Dr. Passavant. A general description of the details of the 250-volt lighting system as used by the German General Electric Company. 4000 w. Elektrotech Zeitschr — July 7, 1898. No. 21764 B.

Illumination.

The Importance of Proper Methods of Illumination. F. A. Bowman. Read at meeting of Can. Elec. Assn. Discusses means of increasing illumination, and the necessity of trying to please customers, if competition is successfully met, and points to this end. 2500 w. Can Elec News—July, 1898. No. 21562.

Meter Tests.

Notes on Some Central Station Meter Tests. William D. Ennis. Reports of recent test of the meter system of a small lighting and power station near New York, with recommendations adopted. 1400 w. Elec Eng, N. Y.—July 7, 1898. No. 21428.

Morley.

Morley Electric Lighting Works. Illustrated description of an English plant. 2500 w. Elec Rev, Lond—July 15, 1898. No. 21649 A.

Regulation.

An Electro Magnetic Regulating System for Arc Lamps. (Ueber Schaltungen von Regelungs elektromagneten bei Bogenlampen.) Th. Weil. Description of an improved arc lamp regulator; with mathematical discussion of the action of the regulating magnets. 3000 w. Elektrotech Zeitschr—June 30, 1898. No. 21762 B.

Pressure Regulator for Alternating Plants. (Fernspannungsregulierung in Wechselstrom Anlagen.) G. W. Meyer. Describing a system of maintaining a constant pressure over an extended area, for an alternating incandescent lighting system. 2500 w. Elektrotech Rundschau—June 15, 1898. No. 21769 B.

Switchboard.

Home Station Switchboard for Toll-line Systems. H. P. Clausen. Illustrated description. 1.00 w. W Elect'n—July 23, 1898. No. 21603.

Vacuum Tubes.

Vacuum Tube Lighting. Reviews the early

development of this form of lighting and describes and illustrates the system. 2500 w. Pro Age—July 1, 1898. No. 21273.

Wakefield.

Wakefield Corporation Electricity Works. Description of an English plant. 3000 w. Elec Rev, Lond—July 8, 1898. No. 21537 A.

Winchester.

Winchester Electric Lighting. Illustrates and describes this English plant. 1400 w. Elec Eng, Lond—July 8, 1898. No. 21534 A.

Wiring.

Changes in Electric Wiring. Harry N. Gardner. Discusses methods which have been in favor but are now considered unsafe; also the methods now in favor. 2500 w. Am Elect'n—July, 1898. No. 21372.

POWER.

Alternating Currents.

The Graphical Treatment of Alternating Currents in Branching Circuits, with Special Reference to the Case of Variable Frequency. Henry T. Eddy. Considers general and special cases. 9000 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21288 D.

See Street and Electric Tramways.

The Commutated Current Wave of a Composite-Wound Alternator. Dugald C. Jackson. Presents a series of curves with comments. 450 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21284 D.

Commercial Plant.

The Technical Arrangements at the Wertheim Stores at Berlin. (Die Technischen Einrichtungen des Warenhauses der Firma A. Wertheim zu Berlin.) A general description of the mechanical installation of a great department store, including power plant, electric lighting, elevators, &c., &c. Two articles. 5000 w. Zeitschr d Ver Deutscher Ing—July 2, 1898. No. 21738 each D.

Dynamos.

Sayers' Automatic Third-Brush Regulation of Dynamos. Describes the arrangement and gives results of some experiments. 500 w. Elect'n, Lond—July 8, 1898. No. 21531 A.

Economical Power.

Economy in Power Installations. Abstract by Charles Weiss from an article in the *Zeitschrift für Elektrochemie*. On the most economical source of energy for central stations. Considers water, steam and gas, but gives comparative costs of the last two named. 2500 w. Engng—July 8, 1898. No. 21545 A.

Electric Power.

See Railway Affairs, Motive Power.

Electric Pump.

See Mining and Metallurgy—Mining.

Exposition.

Electric Service Plant at the Trans-Mississippi and International Exposition. Illustrated description of the plant that furnishes current for the illumination of the grounds and buildings and the operation of motors. 2000 w. W Elect'n—July 23, 1898. No. 21602.

Glasgow.

Electric Power Station at Port Dundas, Glasgow. Plan, cross-section, and front elevation, with description. 1000 w. Engng—June 24, 1898. No. 21323 A.

Hydraulic Plant.

Electric Utilization of Water Powers. L. D. W. Magie. Abstract of a paper read before the Canadian Elec. Assn., at Montreal, Que. Discusses questions requiring study in the harnessing of water powers; also the cost. 1500 w. Elec Wld—July 9, 1898. No. 21403.

Lachine Rapids Plant and the Cost of Producing Power for Generating Electricity Therefrom. W. M'Lea Walbank. A detailed statement of costs, with editorial comment. 2500 w. Elect'n, Lond—July 8, 1898. No. 21530 A.

The Electric Plant of the City of Schaffhausen. (Das Elektrizitätswerk der Stadt Schaffhausen.) K. P. Täuber. A very complete and fully illustrated account of the hydraulic power and electric plant above the Falls of the Rhine. Three articles. 5000 w. Schweizerische Bauzeitung—June 4, 11, 18, 1898. No. 21739 each B.

The "Soo" Water Power. Illustrated description of a plant to develop 40,000 h. p. at Sault Ste. Marie, Mich. 2400 w. Eng Rec—July 23, 1898. No. 21615.

The Utilization of the Falls of Kerka, in Dalmatia. (Project zur Verwerthung der Wasserkraft der Kerkafälle in Dalmatien.) G. Sartori. A detailed description of the hydraulic and electric plant designed to utilize over 7000 h. p. from the river Kerka, near Sebenico, in Dalmatia. Two articles. 3000 w. Electro-Techniker—May 31, June 15, 1898. No. 21770 each B.

Isolated Plants.

Some New Isolated Plants. Part first illustrates and describes some of the plants recently installed in New York, including the Exchange Court Building, Washington Life Ins. Bldg., Cushman Bldg., and Singer Bldg. 3300 w. Elec Wld—July 30, 1898. Serial. 1st part. No. 21672.

Motor.

Economy of a 600-Horse-Power Electric Motor. Describes the remarkable work accomplished by the motor which moves the cable trains on the south side of the city of Chicago. 900 w. Bos Jour of Com—July 2, 1898. No. 21313.

Some Notes on the Practical Use of Single-Phase Alternating Motors. E. E. Hoadley. Facts about the behavior of alternating motors under actual working conditions. 2500 w. Elec Rev, Lond—July 8, 1898. No. 21538 A.

Niagara.

New Work at Niagara Falls by the Hydraulic Company. Orrin E. Dunlap. Illustrates and describes the recent extension of the company's plant. 2000 w. Elec Eng, N. Y.—July 28, 1898. No. 21660.

Power Applications.

Electric Power in Meat-Dressing Establishments. Describes two plants installed in packing houses at St. Joseph, Mo. Ill. 1600 w. W Elect'n—July 16, 1898. No. 21510.

Prague.

Electric Power Station at Laun near Prague. (Elektrische Kraftvertheilungsanlage zu Laun bei Prague). A very full account of the plant at the Government Railway Shops, including electric cranes, transfer table, hoists, &c, with many illustrations. 2500 w. Elektrotech Zeitschr—June 23, 1898. No. 21758 B.

Pumps.

On the Electrical Operation of Conoidal Centrifugal Pumps. John Richards. Read before the Pacific Coast Electric Transmission Assn. Presenting the advantages and disadvantages met, and showing that the latter may be removed. 2400 w. Jour of Elec—July, 1898. No. 21654.

Rolling Mills.

See Mining and Metallurgy, Iron and Steel.

Standardization.

Preliminary Report of the Committee on Standardization. Report submitted for criticism, not yet officially adopted. 5000 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21282 D.

Supply Works.

Morley Corporation Electric Supply Works. Illustrated detailed description of an English plant, with brief history of the undertaking. 3000 w. Elect'n, Lond—July 1, 1898. No. 21451 A.

Towing.

The Development of Electric Canal Towing. (Die Entwickelung der Elektrischen Schiffstauerei.) H. Cox. An illustrated review of the various methods which have been tried for propelling canal boats by electric power. 3500 w. Zeitschr d Ver Deutscher Ing—June 18, 1898. No, 21733 D.

Testing.

Commercial Dynamo and Motor Testing. W. H. Radcliffe. Illustrates and describes methods of testing. 2000 w. Am Elect'n—July, 1898. No. 21370.

Some Tests with an Induction Generator. A. F. McKissick. Tests of an induction motor acting as a generator, driven by a direct-current motor are given, with curves showing the operation. 2400 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21285 D.

Transmission.

A Fourteen Mile Transmission at Barton, Vt., with Monocyclic Apparatus. Illustrated detailed description. 1100 w. Elec Eng, N. Y.—July 21, 1898. No. 21572.

The Cataract Power Company's Transmission Plant. Illustrates and describes a plant for furnishing electric light and power on a large scale at any point on the line from St. Catherines to Hamilton, Ont. 800 w. Elec Wld—July 2, 1898. No. 21361.

TELEGRAPHY AND TELEPHONY.

Baltimore, Md.

The Chesapeake and Potomac Telephone Company, Baltimore, Md. C. B. Fairchild. History of this company, description of equipment, with rules for governing operators. 2500 w. Elec Eng, N. Y.—July 14, 1898. No. 21446.

British Columbia.

The Telegraph in British Columbia. R. B. McMicking. Historical account of the introduction of the telegraph into this province, in connection with the undertaking to connect the old and new world by way of Behring's Strait. 1000 w. Can Elec News—July, 1898. No. 21564.

Central Office.

The Central Office. Dr. V. Wietlisbach. A chapter from the writer's work on "Telephony." Illustrates and describes the apparatus used, in a system which has successfully stood the test of service and is in general use for small offices. 2200 w. Elec Engng—July, 1898. No. 21425.

The Central-Office Equipment of a Successful Independent Telephone Company. H. P. Clausen. Brief illustrated description of a complete exchange system at Wilmington, Del. 2400 w. W Elect'n—July 2, 1898. No. 21373.

Germany.

The Development of the Telephone System of the Imperial Postal Jurisdiction, including Bavaria and Würtemburg. (Entwickelung der Allgemeinen Fernsprechanlagen in Reichs-Postgebiet sowie in Bayern und Würtemberg.) A very complete tabulated account of the German telephone system, with map of the empire, showing the extent and nature of the connections very clearly. 6000 w. Elektrotech Zeitschr—June 9, 1898. No. 21753 B.

High Speed.

High Speed Telegraph Transmission by means of Alternators. Describes the system suggested by A. C. Crehore and G. O. Squire, called the "synchronograph" system, which has been found to produce a distinct increase of speed. 2000 w. Nature—June 30, 1898. No. 21447 A.

Lightning.

Lightning Arresters. A. J. Wurts. Abstract of an address before the Northwestern Elec. Assn. Discusses the power of protection from lightning, considering especially two types of arresters. 2000 w. Elec Wld—July 2, 1898. No. 21362.

Line Signals.

The Evolution of the Line Signal. Arthur Vaughn Abbott. An illustrated account of the progress on lines of telephonic communication, discussing the devices used, and the value of luminous signals. 4500 w. Trans of Am Inst of Engs—May, 1898. No. 21286 D.

Service.

Telephone Service. Dr. V. Wietlisbach. To form a chapter in the writer's work on "Telephony." Suggestions that may be utilized as a basis for rules meeting local conditions. 1600 w. Elec Engng—July, 1898. No. 21426.

Space Telegraphy.

Wireless Telegraphy. Gerald Molloy. An account of Signor Marconi's apparatus and its workings. 1300 w. Ind Engng—June 11, 1898. No. 21495 D.

Telelectroscope.

The Szczepanik Telelectroscope. An account of this invention, with diagrams, as given in the *N. Y. Herald.* An apparatus for the transmission of scenes and pictures over a wire. 1700 w. Elec Eng, N. Y.—July 7, 1898. No. 21429.

The "Telelectroscope" and the Problem of Electrical Vision. Gives the facts made public in regard to the invention of Jan Szczepanik. Ill. 2000 w. Sci Am Sup—July 30, 1898. No. 21681.

Telephone Call.

General Telephone System with Individual Calls. (Einrichtung für Gemeinschaftliche Fernsprechleitungen mit Getrenntem Anruf der Einzelen Theilnehmer.) A system by which a number of individuals may use the same telephone wires and call each other or the central station. 4500 w. Elektrotech Zeitschr—June 16, 1898. No. 21757 B.

MISCELLANY.

Analyzer.

An Harmonic Analyzer. J. N. Le Conte. Describes the instrument and its use. Ill. 1000 w. Phys Rev—July, 1898. No. 21626 D.

Brush Holders.

Some Modern Brush Holders. Illustrated descriptions of various designs. 2400 w. Elec Wld—July 23, 1898. No. 21578.

Condensers.

Experiments on Induction Coil Condensers. Alfred G. Dell. Describes apparatus used and reports experiments made to determine the relation between an induction coil and its condenser. 800 w. Elec Rev, N. Y.—July 20, 1898. No. 21570.

Conductors.

A Simple Method of Determining the Most Efficient Cross Section and the Loss in Electrical Conductors. (Eine Einfache Methode zur Bestimmung des Wirthschaftlichen Querschnittes und Arbeitsverlustes für Elektrische Leitungen.) A. Bull. A mathematical treatment, resulting in practical working equations from which the most economical cross section for any given conditions may be found. 2000 w. Elektrotech Zeitschr—June 9, 1898. No. 21751 B.

Underground Conductors. F. A. C. Perrine. Describes the systems of underground construction which have been used, showing a very satisfactory development for the large cities. Ill. 7800 w. Elec Engng — July, 1898. No. 21424.

Diagrams.

Proposed Standard Diagrams of Electrical Apparatus. Andrew Jamieson. Suggestions for improvement in the figures proposed in American papers, and showing the diversity between American, British and Continental practice. 900 w. Elec Rev, Lond—June 24, 1898. No. 21349 A.

Dielectrics.

Dielectric Strength of Air. Charles Proteus Steinmetz. A report of tests made to investigate this subject, describing methods and giving results. 7500 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21277 D.

Electrical Development.

The Present Status of Electrical Engineering. A. E. Kennelly. Inaugural address presented at the General Meeting of the American Institute of Electrical Engineers 3000 w. Elec Wld—July 9, 1898. No. 21402.

Electrical Discharges.

Disruptive Discharges, Leakage, and Ohmic Resistance. Alex. Jay Wurts. Observations and experience of the writer, with experiments and conclusions. 1700 w. Elec Wld—July 23, 1898. No. 21579.

Electrical Discharge from the Point of View of the Kinetic Theory of Matter. J. E. Moore. Part I, presented to the Faculty of Princeton Univ. for the degree of Doctor of Science. Considers some notions concerning the elementary nature of electrical discharge in gases, which are almost wholly dependent upon the kinetic theory of matter. Ill. 7500 w. Am Jour of Sci—July, 1898. No. 21256 D.

Electrodes.

Aluminum as an Electrode in Cells for Direct and Alternate Currents. E. Wilson. Read before the Royal Society. Deals with the great apparent resistance which aluminum offers to the passage of an electric current when used as an anode in cells containing such an electrolyte as alum in water. 1600 w. Elec Eng, Lond — July 15, 1898. Serial. 1st part. No. 21651 A.

Electrometer.

A Capillary Electrometer for Electrical Measurements. Charles Frederick Burgess. Gives a description of a form of this instrument, enumerating some of its principal characteristics, and calling attention to its applicability for practical electrical measurements. 3500 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21279 D.

France.

Electrical Engineering in France. Edward Conner. Calls attention to the application of electricity to mining purposes in this country. 1500 w. Elec, Lond—July 8, 1898. No. 21521 A.

Galvanic Element.

The Mechanics of the Galvanic Element. (Die Mechanik des Galvanischen Elementes). J. F. Weydl. An attempt to explain the action by the mechanical conception of whirling molecules. Two articles. 3500 w. Elektrotech Zeitschr—June 9, 16, 1898. No. 21752 each B.

Galvanometry.

Ballistic Galvanometry with a Counter-Twisted Torsion System. C. Barus. Explains the use of the ballistic galvanometer by the writer, in a way somewhat different from the ordinary and states the advantages. 1800 w. Phys Rev—July, 1898. No. 21624 D.

High Potentials.

Random Notes on Extremely High Potentials. Leon W. Bly. Observations on extreme high potential workings, discussing the difficul-

ties with transformers and the line. 3500 w. Jour of Elec—July, 1898. No. 21653.

Indicator.

An Indicator for Magnetic Rotating Fields and for Alternating Pressures. (Ein Indikator für Magnetischer Drehfelder und für Wechselstromspannungen.) H. Ebert and M. W. Hoffman. A description of an instrument depending for its action upon the effect of magnetic fields upon cathode rays. 2000 w. Elektrotech Zeitschr—June 23, 1898. No. 21759 B.

Induction Coil.

A Quantitative Study of the High Frequency Induction Coil. W. P. Boynton. A discussion of the mathematical theory with description of experiments made to verify the agreement of the actual behavior of an oscillating system with two degrees of freedom with the approximate theory. 5000 w. Phys Rev—July, 1898. No. 21627 D.

Induction Curves.

A Proposal for Uniformity in the Arrangement of Induction Curves. (Vorschläge zur Einheitlichen Darstellung von Induktionskurven.) Dr. H. Kath. Suggesting the desirability of a uniform system, and advocating that of Siemens & Halske. 600 w. Elektrotech Zeitschr—June 23, 1898. No. 21760 B.

Insulated Wire.

Specifications for Insulated Wire for the Navy. General specifications applying to lighting wire, bell wire and cable. 1600 w. Ind Rub Wld—Aug. 1, 1898. No. 21800 D.

Interrupters.

Rapid Interrupters for Induction Coils. C. Margot, in *La Nature*. Illustrated description of two forms of interrupters. 1000 w. Sci Am Sup—July 2, 1898. No. 21259.

Joint Tests.

Joint Test; Supplement to Raymond Barker's Accumulation Mill Method. A. D. Constable. Investigations made on this method with a view to determining whether in all cases it would prove a satisfactory test. Ill. 1400 w. Elec Rev, Lond—July 8, 1898. No. 21536 A.

Liquid Oxygen.

On the Magnetic Susceptibility of Liquid Oxygen. J. A. Fleming and James Dewar. Read before the Royal Society. Gives results of experiments on the magnetic susceptibility under magnetizing forces varying from 500 to 2500 C. G. S. units. 1400 w. Elect'n, Lond—July 1, 1898. Serial. 1st part. No. 21452 A.

Magnetic Disturbances.

See Street and Electric Tramways.

Magnetic Testing.

A New Magnetic Device of Messrs. Siemens & Halske. (Ein Neuer Magnetisirungs-Apparat der Firma Siemens & Halske.) Dr. H. Kath. A fully illustrated account of a new device for measuring the magnetic character of iron. 3500 w. Elektrotech Zeitschr—June 23, 1898. No. 21761 B.

The Siemens and Halske Magnetic Testing Apparatus. Dr. Hubert Kath. An abstract in English of the above paper. 1400 w. Elec Wld—July 30, 1898. No. 21674.

Magnetization.

An Application of Interference Methods to a Study of the Changes Produced in Metals by Magnetization. J. S. Stevens. Investigations with tabulated results and explanation. 1500 w. Phys Rev—July, 1898. No. 21625 D.

Measurement.

The Direct Measurement of a Quantity of Electricity in Electromagnetic Units. (Sur la Mesure Direct d'une Quantite d'Electricite en Unites Electromagnetiques.) A communication to the French Academy by M. Blondlot, with suggestions as to the construction of an electric meter. 1200 w. Comptes Rendus—June 13, 1898. No. 21723 D.

Ozone.

An Ozonizer for Industrial Purposes. (Un Ozoniseur pour les Applications Industrielles.) E. Andreoli. The apparatus consists of plates studded with sharp points between which the electric discharges take place, a pressure of 3000 volts is used. 3500 w. Electricien—June 11. 1898. No. 21771 B.

Radiography.

An Excursion into the Domain of the X-rays. (Streifzüge durch das Gebiet der X Strahlen.) Dr. Kalischer. A general description of the phenomena of radiography, describing the apparatus and effects. Serial. 1st part. 3000 w. Elektrotech Zeitschr—June 16, 1898. No. 21756 B.

Resistances.

Metallic Resistances. Kilburn Scott. Tables giving resistance, weight, current-carrying capacity, size of mandril, &c., of various alloys suitable for resistance frames and of Hadfield's "Resista," with notes, are given in part first. 1200 w. Elec Rev, Lond—July 15, 1898. Serial. 1st part. No. 21648 A.

On the Bridge Method of Comparing Low Resistances. H. L. Callendar. Some remarks on this method and its great advantage, with illustration of its capabilities. 1200 w. Elect'n, Lond—July 8, 1898 No. 21529 A.

The Electrical Resistance of Steel. (Sur la Resistance Electrique des Aciers.) A communication by M. Le Chatelier, showing the respective influences of carbon, silicon, manganese, nickel, chromium, tungsten and molybdenum upon the resistance of steel. 1000 w. Comptes Rendus—June 13, 1898. No. 21724 D.

The Influence of Tempering upon the Electric Resistance of Steel. (Influes de la Trempe sur lar Resistance Electrique de l'Acier.) A paper by M. Le Chatelier, showing the effect of tempering at various temperatures, both with and without the presence of other substances than carbon. 1000 w. Comptes Rendus—June 20, 1898. No. 21725 D.

Shielding.

Applications of Electromagnetic and Mechanical Shield Action. (Anwendungen Elektromagnetischer und Mechanischer Schirmwirkung.) H. du Bois. A mathematical discussion, with illustrations showing the shielding effect of various devices as indicated by iron filing figures. 3500 w. Elektrotech Zeitschr—June 16, 1898. No. 21755 B.

Specifications.

Electrical Engineers' Specifications. J. Alec. McLaren. Read before the Yorkshire College Engng. Soc. Considers some of the features of interest. Part first discusses penalties, terms of payment, cost of tendering and manufacture, and boilers. 3500 w. Engr, Lond—July 8, 1898. Serial. 1st part. No. 21557 A.

Statistics.

Statistics of Electric Plants in Germany. (Statistik der Elektricitätswerke Deutschland.) An editorial accompanied by very full tables giving valuable data for 388 separate plants up to March 1. 12000 w. Elektrotech Zeitschr—July 7, 1898. No. 21763 B.

Temperatures.

The Chemistry of High Temperatures. Report of the Franklin Institute through its committee on Sciences and the Arts, on the investigations of M. Henri Moissan, with the electric furnace. 2000 w. Jour Fr Inst—July, 1898. No. 21303 D.

Transformers.

Alternating Current Transformers.—From the Station Manager's Viewpoint. W. F. White. Presents some results obtained by a plant in remodeling its transformer system, by using a secondary network, fed by large transformers working in multiple, but located one at each centre of distribution, noting some advantages of the change. 3000 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21280 D.

Design, Construction and Test of a 2 1-2 K. W. Three-Phase, Two-Phase Transformer. A. F. McKissick. Describes work done by T. G. Connor and B. S. Patrick, under the direction of the writer to determine how far theory dictated correct practice. 1200 w. Am Elect'n—July, 1898. No. 21371.

The Construction of a 150,000 Volt Transformer. Ellery B. Paine and Harry E. Gough. A short description of this piece of apparatus designed and constructed as a subject for post-graduate thesis work at the Worcester Polytechnic Inst. Ill. 1500 w. Elec Wld—July 16, 1898. No. 21470.

The Transformation of Alternating Currents. (Sur le Redressement des Courants Alternatifs.) M. P. Janet. A mathematical discussion of the transformation of an alternating into a continuous current. 1000 w. Comptes Rendus—June 20, 1898. No. 21726 D.

Vacuum Tubes.

On the Relation between Pressure, Current, and Luminosity of the Spectra of Pure Gases in Vacuum Tubes. Ervin S. Ferry. Investigations for the purpose of studying photometrically the changes produced in the spectra of pure gases when subjected to various conditions of current and pressure. 1800 w. Phys Rev—July, 1898. No. 21623 D.

Watt Meter.

A Rapid Verification of the Correctness of the Indications of a Watt Meter. (Vérification Rapide l'Exactitude des Indications d'un Watt métre.) M. Aliamet. Intended to enable the correction factor to be obtained for a watt meter which has already been calibrated. 2000 w. Electricien—June 18, 1898. No. 21772 B.

MARINE ENGINEERING.

Anchors.

See Civil Engineering, Harbors.

Chains.

The Wear of Chains. R. Weatherburn. Considers the wear attending the use of chains and the cause. 2800 w. Engr, Lond—July 8, 1898. No. 21555 A.

Disasters.

Responsibility of Steamship Companies in Marine Disasters. Dr. C. E. de M. Sajous. Criticism, called out by the "Bourgogne" disaster, concerning the lack of life-saving appliances furnished, and the causes that hasten the sinking of vessels. 1200 w. Sci Am—July 23, 1898. No. 21583.

Safety at Sea. Editorial on the Bourgogne disaster, and the lessons to be learned by it. 2500 w. Engng—July 15, 1898. No. 21-635 A.

The Prevention of Steamship Collisions. Editorial on the disaster to the steamer "La Bourgogne," criticizing the speed maintained in fogs, and suggesting the improvement of sound signals, and the immediate slackening of speed when signal is heard. 3000 w. Eng News—July 14, 1898. No. 21489.

Fire Boat.

Fire Boat "Robert A. Van Wyck" for the City of New York. Illustrated detailed description. 1200 w. Marine Engng—July, 1898. No. 21-314 C.

Floating Dock.

Proposed United States Naval Floating Dock to be Located at New Orleans. Gives a brief history of the development of this form of dock, merely mentioning the appropriation of the U. S. Congress for the construction of a steel floating and graving dock to be located at Louisiana. Ill. 1500 w. Marine Engng—July, 1898. No. 21316 C.

Kaiser Friedrich.

Concerning the New North German Lloyd Liner Kaiser Friedrich. Notes some of the dimensions and chief characteristics of this ship, and examines the cause of her failing to make a record on her maiden voyage. 1600 w. Marine Engng—July, 1898. No. 21318 C.

Launch.

Coaching Launch Used by the Cornell University Rowing Club. Illustrated description with statement of the requirements of a launch for this use. 1000 w. Marine Engng—July 2, 1898. No. 21317 C.

Metal Coatings.

Experiments upon the Durability of Different Metal Coatings Immersed in Sea Water. An

account of the tests made at the Brooklyn Navy Yard, with table showing the results of protective coatings applied to steel and aluminum plates immersed for 13 months. 1500 w. Eng News—July 28, 1898. No. 21697.

Repairs.

Marine Engine Repairs Discussed in a thoroughly Practical Way. J. Kyles. From a paper read before the Inst. of Engs. and Shipbuilders of Hong Kong. Details are discussed and general suggestions given. 4800 w. Marine Engng—July, 1898. No 21315 C.

Small Craft.

Determination of the Power, Diameter and Pitch of Screws to Propel Small Boats. Facts on these points furnished by a high authority on the subject. The data concerning screws gives the results of recent experimental work. 2000 w. Am Elect'n—July, 1898. No. 21369.

Steamboat.

The New Steamboat Ontegra. Illustrates and describes a new vessel that recently made its first trip on the Hudson River from New York to Catskill. 1800 w. Sea—July 7, 1898. No. 21431.

Steamers.

The New French Steamers for the Channel Service. Illustrated description of the new high-speed steamers for the Channel service, owned y the Northern Railway of France, with a résumé of the conditions under which this company has obtained the contract for conveying the mails between France and England. 2000 w. Engng—June 24, 1898. No. 21322 A.

Turbinia.

The Fastest Vessel Afloat. Cleveland Moffett. An account of the "Turbinia" from personal observation, with discussion of the effect on ocean travel. Ill. 5000 w. McClure's Mag—July, 1898. No. 21269.

Vibration.

The Vibration of Vessels and the Balancing of Marine Engines. (Des Vibrations des Navires et de l'Equilibre des Machines Marines.) M. Haas. A very valuable and complete mathematical and practical discussion of the nature of vibrations in ships and the extent and manner to which they may be diminished by counterbalancing. Two articles, 10000 w. Revue de Mécanique—April, June, 1898. No. 21729 each H.

Yachts.

The High-Speed Steam Yacht as a Factor in Torpedo Boat Design. W. P. Stephens. The concluding article describes and illustrates the swiftest modern steam yachts, and discusses their peculiar features in comparison with torpedo-boat construction. 3500 w. Engineering Magazine—August, 1898. No. 21-797 B.

MECHANICAL ENGINEERING.

BOILERS, FURNACES AND FIRING.

Cost of Labor.

See Economics and Industry, Labor.

Explosion.

Boiler Explosion in an Oil Mill. Illustrates and describes an explosion which shows that repairs were made on a wrong principle. 800 w. Locomotive—June, 1898. No. 21608.

Furnaces.

Boiler Furnaces for Steam Power Installations. M. C. Huyett. Read at Atlantic City meeting of the Am. Soc. of Heat and Ven. Engs. Also discussion. Gives some fuel data as a basis for the discussion of mechanical smokeless furnaces. 2200 w. Heat & Ven—July 15, 1898. No. 21641.

Grate Surface, Chimney Section and Height for Various Fuels. (Rostflächen, Querschnitte und Höhen der Schornsteine für Verschiedene Brennstoffe.) Max Knorr. A discussion with formulas and tables from which the dimensions of parts may be obtained for hard and soft coal, lignite, coke, peat and wood. 3000 w. Gesundheits-Ingenieur—June 30, 1898. No. 21742 B.

Heat Transmission.

The Transmission of Heat Through Plates from Hot Gases to Water. George Halliday. A paper read at the Sheffield, Eng., meeting of the Institution of Engs. and Shipbuilders in Scotland. Presents the leading known facts on this question. 2500 w. Ind & Ir—June 24, 1898. Serial. 1st part. No. 21320 A.

High Pressure Steam.

See Mining and Metallurgy—Mining.

Petroleum.

Petroleum Vapor; Its Production and Use. J. S. V. Bickford. Results of experience in the fields of petroleum Bunsen burner, and petroleum blow-pipe work. Ill. 4200 w. Eng, Lond—July 15, 1898. No. 21628 A.

Riveting.

Causes of Certain Steam Boiler Explosions. (Causes d' Explosion de Certaines Chaudières.) A review of M. Fremont's paper upon the injury to the metal which is caused by careless treatment in riveting. Serial. 1st part. 2500 w. Le Génie Civil—July, 9, 1898. No. 21717 D.

Smoke.

A Method of Estimating Smoke. (Méthode d'Estimation des Fumées.) Max Ringelmann. A description by Prof. Ringelmann of his smoke scale for classifying the degrees of smokiness of a factory chimney; showing how the scale is constructed and used. 2000 w. La Revue Technique—June 25, 1898. No. 21702 D.

The Hinstin Smokeless Furnace. (Les Foyers Fumivores de M. J. Hinstin.) Describing and illustrating the Hinstin furnace as applied to steam boilers, and accepted by the municipal authorities for use within the city limits of Paris. 1200 w. La Revue Technique—July 10, 1898. No. 21708 D.

Water Columns.

Water Column Connections. H. H. Kelly.

Calls attention to some elements of danger arising from the neglect of water columns, or of wrong connections. Ill. 1400 w. Sci Mach—July 1, 1898. No. 21365.

Water-Tubes.

The Problem of Combustion in Water-Tube Boilers, and a Means of Its Solution. James Weir. Paper read at meeting of Inst. of Engs. and Shipbuilders in Scotland. Analyzes the phenomena of combustion, showing why it is defective and giving a solution. An important paper. Discussion. Ill. 5500 w. Steamship—July, 1898. No. 21448 A.

COMPRESSED AIR.

Air Receivers.

Constant Pressure Air Receivers. E. A. Rix. Describes a way to overcome the volumetric loss. It consists in having a pipe connected at the lowest point of the receiver, and with a water tank high enough to give constant pressure. 1200 w. Am Mach—July 7, 1898. No. 21360.

Compressor.

A Simple Air Compressor. C. P. Turner. Illustrated description of the hydraulic air compressor. 1400 w. Min & Sci Pr—June 25, 1898. No. 21264.

Liquefied Air.

Liquefied Air for Industrial Purposes. From *La Nature*. Illustrated description of Dr. Linde's apparatus which produces about 28 ounces of liquefied air per hour with an expenditure of 3 h. p. to actuate the pumps. 1000 w. Sci Am Sup—July 2, 1898. No. 21261.

Liquefied Air. George F. Barker. Considers the processes for liquefying air, its appearance, means of transportation, effect on other substances, applications, &c. 2500 w. Chau—Aug., 1898. No. 21663 C.

Water Blast.

On a New Form of Water Blast. Bertram B. Boltwood. Describes and illustrates the essential parts of the apparatus and its action, stating the advantages and giving result of tests to determine the efficiency. 1000 w. Am Chem Jour—July, 1898. No. 21497 D.

ENGINES AND MOTORS.

Agricultural Motors.

International Competition of Agricultural Motors. (Concours International des Moteurs Agricoles.) Camille Lambotte. An illustrated review of the steam and petroleum motors for agricultural service as shown at the Brussels exhibition in 1897. 3000 w. Revue Universelle des Mines—June, 1898. No. 21718 H.

Air Pumps.

Independent Air Pumps of Marine Engines. A. B. Willets. Presents the many advantages, and the methods of working, &c. Ill. 1600 w. Ir Age—June 30, 1898. No. 21242.

Compound Engines.

Non-Condensing Compound Engines for Office Buildings William H. Bryan. A letter advocating their use in place of simple engines. 1000 w. Eng Rec—July 2, 1898. No. 21311.

Non-Condensing Compound Engines for Office Buildings. Letters from Charles G. Darrach and Phœnix Iron Works Co, comparing the advantages of condensing and non-condensing engines for such service. 1200 w. Eng Rec—July 9, 1898. No. 21422.

Compression.

The Compression of Steam in the Clearance Space. (La Compression de la Vapeur dans l'Espace Mort.) J. Boulvin. A critical review of the experiments of Prof. Dwelshauvers Dery, showing that the losses charged to compression of the exhaust steam are those inevitably due to the action of the cylinder walls. The entropy diagram is applied in an instructive manner. 7000 w. Revue de Mécanique—June, 1898. No. 21728 H.

Gas Engines.

Small Gas Engine Cylinders. Herbert L. Towle. Discusses the influence of cylinder diameter on efficiency, showing the low economy of small cylinders and the advantages of multi-cylinder arrangement. 1500 w. Am Mach—July 28, 1898. No. 21678.

Indicator.

A New Continuous Recording or Integrating Engine Indicator. Illustrates and describes an instrument invented by W. G. and C. W. G. Little, of Bexley, Kent, England, and explains its operation and theory. 1700 w. Eng News—July 28, 1898. No. 21696.

Lubrication.

The Lubricating of Engine Cylinders. Considers the principal causes of cutting and grooving. 1400 w. Bos Jour of Com—July 23, 1898. No. 21604.

Oil Engines.

Oil Engines. Capitaine v. Diesel. Discussion of a paper by E. Capitaine criticizing the theory propounded by Herr Diesel and the results he has obtained. 4000 w. Engr, Lond—July 8, 1898. No. 21554 A.

Steam Engine.

The Criticisms of the Steam Engine. (Ueber die Beurteilung der Dampfmaschine.) Richard Mollier. A discussion of the theoretical thermal and mechanical efficiencies of the steam engine, in comparison with results obtained by actual test. A large comparative table is given. 4500 w. Zeitschr d Ver Deutscher Ing—June 18, 1898. No. 21732 D.

Testing.

Four Days' Tests on a Sulzer Triple Steam Pumping Engine. Summary by Bryan Donkin, of an interesting set of tests made by Prof. Stodola, of Zurich. 500 w. Engr, Lond—July 1, 1898. No. 21469 A.

Traction Engines.

Something About Traction Engines. Joseph B. Hall. On their principal uses and the treatment they receive. Ill. 1000 w. Am Mach—July 21, 1898. No. 21580.

Valves.

Friction out of Throttle Valves. An editorial pointing out the wire-drawing resulting from valves of bad form. 500 w. Eng Rec—July 23, 1898. No. 21610.

POWER AND TRANSMISSION.

Elevator.

The Reno Inclined Elevator in a Department Store. Illustrates and describes the installation of this elevator in the department store of Bloomingdale Bros., New York. 1200 w. Elec Eng, N. Y.—July 7, 1898. No. 21427.

Gas Power.

Gas Power. J. Barton. Read before the Federated Inst. of Min. Engs., England. Giving some practical results of working engines with generator gas. 2500 w. Pro Age—July 1, 1898. No. 21275.

The Operating Cost of Gas Power Plants. (Die Betriebskosten von Gasmotorenanlagen.) J. Körting. A discussion of the operative cost of gas engines as compared with steam including all fixed charges, and considering various kinds of gas. 3500 w. Zeitschr d Ver Deutscher Ing—June 18, 1898. No. 21735 D.

The Utilization of Blast Furnace Gas as Motive Power. (De l'Emploi des Gaz de Hauts Fourneaux comme moteurs.) An account of the experiments at Seraing, Belgium, with illustration of the 200 h. p. gas engine operated by furnace gases. 3000 w. La Revue Technique—July 10, 1898. No. 21706 D.

Hoisting Machines.

The Brown Hoisting and Conveying Machines. Axel Sahlin. Paper read before a special meeting of the Düsseldorf branch of the Verein Deutsche Eisenhüttenleute. Introductory remarks on the conditions that have enabled the United States to compete with Europe in the iron and steel industry, followed by illustrated description of the Brown machines. 5800 w. Engng—July 8, 1898. No. 21542 A.

Hydraulic Plant.

See Electrical Engineering, Power.

Piping.

Neglected Considerations in the Arrangement of Steam Piping. W. Cooper. A careful discussion of the correct proportions of steam piping, showing the causes for loss, and the best methods of meeting them. 3500 w. Engineering Magazine—August, 1898. No. 21793 B.

Transmission.

A Topical Discussion Upon Electrical, Pneumatic and Mechanical Power Transmission in Manufacturing Establishments. Ill. 12000 w. Jour W Soc of Engs—June, 1898. No. 21436 D.

Transportation.

Overhead Tramways. Henry Wysham Lanier. An interesting illustrated account of the wire ropeway construction for getting into the gold regions of the Yukon basin. 2500 w. Chau—Aug., 1898. No. 21664 C.

Water Wheels.

A Complete Theory of Impulse Water Wheels and Its Application to Their Design. R. T. Kingsford. Mathematical demonstration. 2500 w. Eng News—July 21, 1898. No. 21595.

SHOP AND FOUNDRY.

Ball Bearings.

A Theoretical Study of Ball Bearings. (Etude Theorique sur les Roulements à Billes.) C. Bourlet. A valuable discussion, with many diagrams, showing the mechanical action of the various forms in use with their advantages and disadvantages. Two articles. 6000 w. Le Génie Civil—July 2, 9, 1898. No. 21715, each D.

Belt Holes.

Plotting Belt Holes in Floors and Partitions by Proportion. M. H. Avery. Letter to editor, with illustration, explaining method used by writer. 500 w. Am Mach—June, 1898. No. 21248.

Brass.

Melting, Mixing, and Casting Brass. John A. Macauley. Considers only mixtures in everyday use which are of practical value. 1600 w. Foundry—July, 1898. No. 21478.

Casting.

Centrifugal Casting. (Ueber Zentrifugalguss.) Ernst Lewicki. Describing the centrifugal method of obtaining sound castings. The mould is revolved rapidly, forcing the melted metal to the circumference. 3500 w. Zeitschr d Ver Deutscher Ing—June, 25, 1898. No. 21737 D.

Making a Large Standardizing Casting. Thomas D. West. Read before the Pittsburg Foundrymen's Assn. Gives plan for obtaining 300 pounds or more of absolutely clean and uniform drillings for standardizing purposes. Ill. 1200 w. Ir Trd Rev—June 30, 1898. No. 21271.

Cast Iron.

On the Molecular Changes in Cast Iron Caused by Vibration. Report of the Franklin Institute, through its Committee on Science and the Arts, on the investigations of A. E. Outerbridge, Jr. 700 w. Jour Fr Inst—July, 1898. No. 21304 D.

Cone Pulleys.

A New Cone Pulley Diagram. From a pamphlet by Walter H. Palmer. Diagram for open belts with description of its application. 1100 w. Am Mach—July 14, 1898. No. 21472.

Dividing Device.

The Mundo Wheel Dividing Device. Morris Fulton. Illustration with description and mode of operation. 2000 w. Am Mach—July 21, 1898. No. 21581.

Furnace.

The Baumann Tilting Pre-Heating Crucible Furnace. (Baumann's Aufkippbar Vorwärmar-Tiegelofen.) An ingenious form of crucible furnace in which the charge is heated by the escaping gases before entering the crucible. 1200 w, Stahl und Eisen—June 15, 1898. No. 21745 D.

Gear Teeth.

Dimensions of Gear Teeth in the Metric System. Peder Lobben. Explains the application of the metric system to gear calculations. 350 w. Am Mach—June 30, 1898. No. 21245.

Table of Strength of Cut Gear Teeth. Henry Hess. A table prepared to allow the pitch and

the face to be found with very little arithmetic. It is based on Lewis' method of calculating the strength of gear teeth. 800 w. Am Mach—July 7, 1898. No. 21359.

Geneva Stop.

Three Modifications of the Geneva Stop. Illustrated description of three modifications of the device used in watches to prevent over-winding which have been recently applied by Hugo Bilgram to various automatic machines. 1500 w. Am Mach—June 30, 1898. No. 21246.

Index Plate.

Making an Accurate Index Plate. G. P. Wetmore. Illustrates and describes the manner of doing the work. 1000 w. Am Mach—July 7, 1898. No. 21356.

Lathes.

Some Tools Used in Lathe Building. W. L. Shellenback. Illustrated description of devices and manner of using them. 500 w. Am Mach—July 7, 1898. No. 21358.

Lathe Testing.

Tools for Lathe Testing. Oscar E. Perrigo. An illustrated account of a simple and not expensive apparatus for this purpose. 1000 w. Am Mach—July 21, 1898. No. 21582.

Metal Work.

Cast Metal Work from Benin. Illustrates and describes the pieces showing high artistic excellence, brought from West Africa. 1600 w. Nature—July 1898. No. 21522 A.

Molding.

Stripping Plate Molding Machines. E. H. Mumford. Read before the New England Foundrymen's Assn. Discusses some of the problems arising with machines for general work, quoting from a letter from John C. Meloon, giving his experience with stripping plate patterns in constant use. 2200 w. Ir Trd Rev—June 30, 1898. No. 21272.

Rivets.

The Shearing Resistance of Steel Rivets. An editorial review of the basis of current practice. 800 w. Eng Rec—July 2, 1898. No. 21305.

Shop Costs.

Effective Methods of Finding and Keeping Shop Costs. Henry Roland. A descriptfon of the system used by the Hyatt Roller Bearing Company, with copies of blank forms, books, &c., and all working details. 4000 w. Engineering Magazine—August, 1898. No. 21794 B.

Studs.

Some Practical Hints on the Making of Studs. F. F. Hemenway. Illustrates and describes a method used by the writer. 1200 w. Prac Eng—July 1, 1898. No. 21450 A.

Tapping.

A Tapping Tool. A. H. Cleaves. Illustrates and describes a convenient tool. 400 w. Am Mach—July 14, 1898. No. 21471.

MISCELLANY.

Areas.

The Truth and Errors of Mr. Wiener's Method of Finding the Area of Curvilinear Figures. J. J. Guest. A demonstration of the method in proof of its truth. 800 w. Am Mach—July 7, 1898. No. 21357.

Wiener's Method of Graphic Integration. Leicester Allen. Highly commending the method, and giving some points in its application. Ill. 1500 w. Am Mach—July 28, 1898. No. 21677.

Automobiles.

Competition of Automobile Hackney Carriages. Illustrates some of the vehicles that took part in the competition in France. 400 w. Sci Am Sup—July 2, 1898. No. 21258.

The Automobile Cab Competition. (Le Concours de Fiacres Automobiles.) C. Bontain. A detailed account of the prize competitions of the Automobile Club of Paris, with photographs of the vehicles, and a map of the routes. 3 00 w. 1 plate. La Revue Technique—June 25, 1898. No. 21704 D.

The Automobile Exhibition of the Tuileries. (L'Exposition d'Automobiles des Tuileries.) The first of a series of articles illustrating and describing the vehicles exhibited at the exposition held by the Automobile Club, after the cab competition in Paris. Serial. 1st part. 1200 w. La Revue Technique—July 10, 1898. No. 21710 D.

The Competition for Automobile Cabs. (Concours pour Voitures de Place Automobiles.) A general account of the Automobile Club competition, with a review of the performance of the various competing vehicles. 2500 w. Le Génie Civil—June 25, 1898. No. 21713 D.

The Patin Electrical Motor Carriage. Illustrated description of a carriage designed by M. O. Patin, possessing several novel features. 800 w. Ind & Ir—June 24, 1898. No. 21321 A.

The Paris Motor-Cab Competition. An account of the trials promoted by the French Automobile Club, with illustrated descriptions of the vehicles entered. 4300 w. Automotor Jour—July, 1898. No. 21665 A.

The Weidknecht and Bourdon Steam Omnibus. Illustrated description of this vehicle. 600 w, Automotor Jour — July, 1898. No. 21666 A.

Bicycles.

Bicycle Efficiency Tests. A. H. Eldredge and G. B. Preston. A description of the method of testing, with a comparison of the efficiency of different types of bicycles under various conditions, and the relative efficiency of solid, cushion and pneumatic tires. Ill. 4000 w. Mach, N. Y.—July, 1898. No. 21244.

Elasticity.

The Law of Elasticity and its Practical Application. (Das Elastizitatsgesetz und seine Anwendung für Praktische Rechnung.) Rudolph Bredt. A mathematical discussion of the relation between stress and strain with examples of application to practical computation. 4000 w. Zeitschr d Ver Deutscher Ing—June 18, 1898. No. 21734 D.

Liquid Air.

Liquid Air. (L'Air Liquide.) A communication to the French Academy by M. d'Arson-

val, relating the results of his experiments with the Linde apparatus. 2500 w. Comptes Rendus—June 13, 1898. No. 21722 D.

Lubrication.

Lubrication from an Engineer's Point of View. William M. Davis. Reviews some of the laws relating to friction, and discusses the value of oils used, and the conditions affecting lubrication. 1500 w. Sci Mach—July 1, 1898. No. 21366.

Sampling and Testing Lubricating Oils and Fats in the Workshop. Instructions for ascertaining whether a lubricating oil or fat is pure or not, and, if not, what is the nature of the adulterating body. 2000 w. Engr, Lond—July 15, 1898. Serial. 1st part. No. 21629 A.

Oxygen.

The Industrial Preparation of Oxygen. (Préparation Industrielle de l'Oxygene.) P. Crépy. A description of the Garuti process of making oxygen on a commercial scale by the electrical decomposition of water. 1000 w. La Revue Technique — July 10, 1898. No. 21707 D.

Pipe Coverings.

The Selection of Steam Pipe Coverings. Editorial on fallacy of judging the efficiency of coverings by tests of short duration. 800 w. Eng Rec—July 2, 1898. No. 21306.

Testing Machine.

The Laboratory Testing Machine at University College, Cardiff. Extracts from a lecture delivered to the Inst. of Junior Engs., England, by A. C. Elliott. Illustrated detailed description of the machine and its operation. 4400 w. Engng—July 1, 1898. No. 21463 A.

Testing.

Testing Material for Rolling Stock. George T. Glover. An account of the present requirements for railway rolling-stock material in England, and the manner in which the tests are carried out. 2000 w. Engr, Lond—July 1, 1898. Serial. 1st part. No. 21467 A.

The Accuracy of Testing Machines and the Results of Rupture Tests. (Ueber die Genauigkeit der Festigkeitsmaschinen und der Ergebnisse von Zerreissversuchen.) Prof. B. Kirsch. A comparison of tests made upon identical specimens of various machines, showing the probable error due to the apparatus. 3000 w. Stahl und Eisen—June 15, 1898. No. 21746 D.

Tests,

On Comparative Tests. W. H. Booth. On the unreliability of such tests. 1500 w. Am Mach—July 28, 1898. No. 21675.

MILITARY ENGINEERING.

Ambulance Service.

The Red Cross Society and the Ambulance Service. Short account of the society with illustrated description of the ambulance service. 1200 w. Sci Am—July 23, 1898. No. 21585.

Battleship.

H. M. S. Albion. Describes the vessel and her armament, calling attention to interesting features in the design. 2200 w. Engng—June 24, 1898. No. 21226 A.

H. M. S. Amphitrite. Illustration with description of ship and armament. 900 w. Engr, Lond—July 15, 1898. No 21630 A.

The Demand for Faster Battleships. Editorial urging the importance of speed, and commenting on the lessons to be learned from the recent destruction of the Spanish fleet. 2500 w. Eng News—July 21, 1898. No. 21596.

The Spanish Battleship "Pelayo." Describes and illustrates this formidable vessel of the Spanish navy, and its armament. 2800 w. Sci Am Sup—July 16, 1898. No. 21476.

The Vitals of a Battleship. Richard Lee Fearn. Description of the battleship Iowa. Ill. 2200 w. Chau—Aug., 1898. No. 21662 C.

Bullets.

The Causes of the Explosive Effect of Modern Small Calibre Bullets. Charles E. Woodruff. Part first explains the vibrations of wave motions and their effects, and attributes the explosive effect to the capability or incapability of the tissues to transmit these wave motions. 3800 w. Sci Am Sup—July 2, 1898. No. 21263.

Commerce-Destroyers.

Confederate Commerce-Destroyers. I. The Tallahassee's Dash into New York Waters. John Taylor Wood. An account of the cruise of this vessel by her commander. II. The Eventful Cruise of the Florida. G. Terry Sinclair. A former midshipman's account. Ill. 12200 w. Century Mag—July, 1898. No. 21257 D.

Cruiser.

Fourth-Class Cruiser "G" of the German Navy. From *Illustrirte Zeitung*. Brief description with illustration of a vessel being constructed at Krupp's Germania Dock, at Kiel. 400 w. Sci Am Sup—July 30, 1898. No. 21682.

H. M. Cruiser "Highflyer." Illustrated description of a second-class cruiser, recently launched. 1800 w. Engs' Gaz—July, 1898. No. 21449 A.

The Argentine Cruiser "General San Martin." Illustrated description of vessel and equipment, with report of trials. 1800 w. Engng—July 15, 1898. No. 21634 A.

The Machinery of the Dutch Cruiser "Friesland." The particular feature is the use of water-tube steam generators in combination with boilers of the ordinary cylindrical type. Ill. 700 w. Engng—July 1, 1898. No. 21464 A.

The Reconstructed Cruiser "Newark." Describes the vessel as first constructed and the alterations made. Ill. 1300 w. Sci Am—July 23, 1898. No. 21584.

The United States Armored Cruiser "Brooklyn." Illustrated description of this vessel and her armament, with report of official speed trial. 2800 w. Sci Am—July 16, 1898. No. 21474.

Guns.

Concerning Our New Cannon. (A Propos Notre Nouveau Canon.) Leo Dex. A discussion of the present French field piece in comparison with guns of the Maxim-Nordenfelt type. 1500 w. La Revue Technique—June 25, 1898. No. 21701 D.

The Krupp 7.5 Cm. Rapid Fire Gun in the Cuban Campaign. Atanasio Torres. Reviews the causes that led to the adoption of this gun in the Spanish army, the difficulties which interfered with the proper equipment of the batteries, and a discussion of its use in the Cuban campaign. 6500 w. Jour of U S Artillery—May, June, 1898. No. 21442 D.

The Sims-Dudley Powder Pneumatic Gun. Illustrated description of a gun, known as a dynamite gun, though really charged with Nobel's gelatine. 1000 w. Am Mach—July 28, 1898. No. 21676.

Working a Big Gun. Brief account of how the 13-inch destroyer is operated in a battle. 600 w. Bos Jour of Com—July 2, 1898. No. 21312.

Military Bridges.

Military Bridges. Illustrated extracts from U. S. War Dept. manuals. 2000 w. Eng Rec—July 16, 1898. No. 21504.

Military Power.

The Fighting Strength of the United States. F. W. Hewes. A comparison of the resources of the several nations. Ill. 2500 w. McClure's Mag—July, 1898. No. 21270.

Military Roads.

Road Manual for the U. S. Armies of Invasion. Reprint of instructions for use of the forces invading Spanish colonies, prepared by Gen. Roy Stone of Gen. Miles' staff. 1400 w. Eng Rec—July 2, 1898. No. 21310.

Naval Programme.

The Navies and Naval Construction Programme of 1898. H. W. Wilson. A review of the present tendencies in naval design, armament, and engineering, with especial reference to the new construction work of the present year. 3500 w. Engineering Magazine—August, 1898. No. 21790 B.

Spanish Fleet.

The Remains of Cervera's Fleet. Illustrated description of the vessels showing the effect of the recent battle. 1400 w. Sci Am—July 30, 1898. No. 21679.

Targets.

Moving Targets in Use in the Light Artillery of England, Germany, France, Italy, and Some Forms Recently Tried by the Light Artillery Battalion at Fort Riley, Kansas. C. G. Treat. Illustrated description of moving targets for gunner's practice. 3400 w. Jour of U S Artillery—May-June, 1898. No. 21441 D.

Torpedoes.

The Whitehead Torpedo. W. J. Sears. From the Pro. of the U. S. Naval Inst. Illustrated description, with a brief summary of its preparation for a run. 6000 w. Engng—July 15, 1898. No. 21639 A.

MINING AND METALLURGY.

COAL AND COKE.

Anthracite.

Anthracite in the Rockies. R. M. Hosea. The causes which produced it and the methods used in mining and preparing it. A geographical and geological description of the region in which it is found and some of the peculiar difficulties met with in exploiting the properties. Ill. 4800 w. Mines & Minerals—July, 1898. Serial. 1st part. No. 21404 C.

Charcoal Kiln.

The Ljungberg Continuous Charcoal Kiln. E. J. Ljungberg. States the principles to be observed, and describes the continuous kiln and its operation. 3500 w. Ir Age—July 28, 1898. No. 21669.

Coal Preparation.

Coal Preparation and Washing Plant at a Westphalian Colliery. E. Tomson. From a communication to the jubilee meeting of the Liége Engs'. Assn. Illustrates and describes a double picking and screening plant, and a washing plant for the nuts and slack, capable of dealing with 100 tons per hour. 1500 w. Col Guard—July 1, 1898. No. 21454 A.

Coal Supplies.

The Coal Supplies of the World. Benjamin Taylor. An interesting review of the production, importance and consumption of this mineral in all parts of the world, with special statistics of the English supply. 7300 w. Nineteenth Cent—July, 1898. No. 21778 D.

Coking.

On Coking in By-Product Ovens. John H. Darby. Read before the Iron and Steel Inst. Data showing that well-made retort coke is economical in the blast-furnace, and that some fuels that will not coke satisfactorily in the beehive ovens, will produce a marketable coke in the retort oven. 2500 w. Engng—July 1, 1898. No. 21466 A.

Deposits.

Coal Find and Mining Operations Between Boulogne and Calais. Abstract of report of M. Olry. Favorable to the sinking of a shaft in this district giving information of the deposit. 2300 w. Col Guard—July 1, 1898. No. 21457 A.

Explosives.

The Testing of Explosives for Use in Coal Mines. A report by A. Cooper-Key, inspector of explosives at the Home Office Testing Station, Woolwich, England. 3500 w. Col. Guard—July 8, 1898. No. 21550 A.

Haulage.

Förster and Dinnendahl Arrangements for Rope Haulage. Leon Navez. From a communication to the Société des Ingénieurs des

Mines du Hainaut. Illustrates and describes two systems much used in Germany, which give excellent results. 1200 w. Col Guard—June 24, 1898. No. 21330 A.

Mining Haulage. G. W. Westgarth. Abstract of paper read before the British Society of Mining students. Considers the systems of rope haulage and their cost. 1800 w. Ir & Coal Trds Rev—July 8, 1898. No. 21547 A.

Hydrometers.

Experiments on Hydrometers and Anemometers. Prof. Rateau. From *Annales des Mines.* Experiments with these measuring instruments to determine the degree of approximation obtainable in the various circumstances, and the causes which diminish that approximation. 3000 w. Col Guard—July 8, 1898. Serial. 1st part. No. 21548 A.

Nova Scotia.

A Nova Scotia Coal Mine. An illustrated account of the mines of the Cumberland Railway and Coal Company. 5000 w. Ir & Coal Trds Rev—July 8, 1898. No. 21546 A.

Production.

Coal Production, Consumption and Value. Editorial on the report of the British Board of Trade regarding the fuel supply of the world. 1300 w. Engng—June 24, 1898. No. 21325 A.

Russia.

Coal and Iron in Russia. From a Consular Report. Reports concerning these industries, giving production. 1500 w. Col Guard—July 1, 1898. No. 21458 A.

South Africa.

The Coal Fields of South Africa. Reports concerning the increased activity and competition in this district, mentioning individual collieries. 1000 w. Col Guard—July 8, 1898. Serial. 1st part. No. 21553 A.

COPPER.

By-Products.

The Relation of By-Products to Cost of Copper Production. Discusses the margin of profit between cost of production and selling value. Gives information of the Anaconda, the Boston & Montana, and the Rio Tinto. 1200 w. Eng & Min Jour—July 9, 1898. No. 21432.

Copper Deposits.

The Origin and Mode of Occurrence of the Lake Superior Copper Deposits. M. E. Wadsworth. A general idea of the geology of this region and the writer's explanation of the facts observed. 13000 w. Trans Am Inst of Min Engs—July, 1897. No. 21620 D.

Mines.

The Stora Kopperberg's Great Copper Mines at Falun. Illustrated detailed description of one of the oldest mines in the world. 3000 w. Ir & Coal Trds Rev—July 15, 1898. No. 21350 A.

Refining.

Progress in Electrolytic Copper Refining During 1897. Titus Ulke. From "The Mineral Industry," Vol. VI. Brief review of improvements in mechanical details and chemical methods, describing various modes of treatment. 4500 w. Eng & Min Jour—July 2, 1898. No. 21355.

Tamarack Mine.

Some Notes on a Lake Superior Copper Mine. Photographs of underground workings of the Tamarack mine in Michigan, with notes. 700 w. Eng & Min Jour—July 9, 1898. No. 21433.

GOLD AND SILVER.

Beating.

Gold Beating. O. G. Holt. An interesting description of the process which is practiced very much as it was three thousand years ago. 1800 w. Sci Am—July 30, 1898. No. 21680.

Cyanid.

Notes on the Application of Oxygen in the Cyanid Process. H. T. Durant. Considers the use of atmospheric or molecular oxygen, and the methods of application, giving the results of experiments made. Ill. 1800 w. Jour of Chem & Met Soc of S. Africa—May, 1898. No. 21655 E.

The Cyanid Process. J. Stanley Muir. Discusses the means of ascertaining what ores are amenable to this treatment, the necessity of expert examination in order to get the most profitable results, with description of the process. 2000 w. Min Rept—July 7, 1898. No. 21559.

The Cyanid Process. Louis Fade. Read before the International Mining Congress at Salt Lake City. Discusses the preliminary treatment of the ore, crushing, sorting, &c., the Elsner theory, and the success of the process. 2800 w. Min & Sci Pr—July 16, 1898. No. 21592.

Utah's Latest Triumph. An illustrated detailed description of the great De La Mar cyanid plant at Mercur, and its operation. 3000 w. Min Rept—July 21, 1898. No. 21640.

Dredging.

Dredging in New South Wales. An interview with Mr. C. L. Garland regarding the progress made in dredging for gold, which gives promise of satisfactory results. 2000 w. Aust Min Stand—June 9, 1898. No. 21576 B.

Georgia.

Gold Mining in Georgia. William Tatham. An account of the mines and mining and the opportunities for those possessing capital and experience. 2800 w. Jour Fr Inst—July, 1898. No. 21299 D.

Gold Milling.

Gold Milling in Colorado. John Roger. The first of a series of articles proposing to give an accurate description of three gold mills recently erected in Colorado, dealing with the subject more especially from a mechanical point of view. Ill. 2200 w. Engng—July 1, 1898. Serial. 1st part. No. 21462 A.

Gold Mining.

The History of Gold Mining. M. C. Ihlseng. An extract from an illustrated lecture delivered before the Engineers' Club, of Scranton, Pa. 2500 w. Mines & Min—July, 1898. No. 21406 C.

Gold Recovery.

Recovery of Gold from Low Grade Ores. Describes a new process recently tried with great success in California. 900 w. Sci Am—July 23, 1898. No. 21586.

Guiana.

The Gold Fields of Guiana. H. Tweddle. Historical sketch with illustrations. 6000 w. Eng & Min Jour—July 23, 1898. No. 21609.

India.

The Gold Resources of India. William King and Theodore Wm. Hughes Hughes. An exhaustive review of the gold regions of India, with especial regard to the Mysore District. 5000 w. Engineering Magazine—August, 1898. No. 21798 B.

Lodes.

Australian Lodes and Fissures. William Davey. The writer having had large experience in mining, gives some opinions relating to the conditions under which gold may be reasonably expected. Ill. 3500 w. Aust Min Stand—May 19 & 26, 1898. Serial. 2 parts. No. 21335 each B.

Theories of the Formation of Lode Matter. F. Sandberger. Translated from the German. Discusses the ascension and lateral secretion theories from a chemical, geological standpoint. 6500 w. Aust Min Stand—May 26, and June 2, 1898. Serial. 2 parts. No. 21337 each B.

Peculiar Mine.

A Peculiar Ore Body. Arthur Lakes. Describes a peculiar mine near Cripple Creek and how the method of working resulted in a serious accident. 1200 w. Mines & Min—July, 1898. No. 21410 C.

Precipitation.

Statement as to My Process of Precipitating Gold by Means of Copper Salts. P. de Wilde. Replies to the objections, from various quarters, to the writer's process for precipitating gold from solutions of cyanid by means of sulphurous acid and sulphate of copper. 1700 w. Jour of Chem & Met Soc of S. Africa—May, 1898. No. 21657 E.

Prospecting.

A Guide for Prospectors. W. C. Wynkoop. The first of a series of articles intended to aid prospectors, and giving such information as will enable one to recognize valuable ores when discovered. 2000 w. Min Repts—July 7, 1898. Serial. 1st part. No. 21560.

Saddle Reefs.

Saddle Reefs at Hargraves, New South Wales. J. Alex. Watt. Description of these reefs with illustrations. 2800 w. Aust Min Stand—June 9, 1898. No. 21577 B.

Silver-Lead.

Mount Deddick Silver-Lead Field. Full text of the government geologist's report on this Australian field, with sketch plans. 2000 w. Aust Min Stand—May 26, 1898. No. 21336 B.

Sulphurets.

Experimenting with and Processes by Which Sulphurets from the Plymouth Rock, Cal., Mine are worked. T. K. Code. Gives details of the experiments and results. The process by which the ores are now worked. Costs $6.50 per ton. 900 w. Min & Sci Pr—June 25, 1898. No. 21265.

Tailings.

The Treatment of Tailings in the Witwatersrand. E. P. Chester. Illustrated description of the process in use. 1100 w. Eng & Min Jour—July 2, 1898. No. 21354.

Tellurium.

Tellurium and the Telluride Ores of Cripple Creek, Colorado, as illustrated by specimens in the State Mining Bureau, Denver. Arthur Lakes. Information concerning these ores, their appearance and detection. 3800 w. Mines & Min—July, 1898. No. 21405 C.

Victoria.

Gaffney's Creeek (Vic.). Gives views and details of some of the principal mines of this district. 2000 w. Aust Min Stand—June 2, 1898. No. 21338 B.

Vulcan Mine.

Ores of the Vulcan Mine. Arthur Lakes. A strange mine in Colorado with remarkable formations and a peculiar gold-bearing rock. 2000 w. Mines & Min—July, 1898. No. 21411 C.

IRON AND STEEL.

Bessemer Process.

The Thermo-Chemistry of the Bessemer Process. Noel Hartley. Gives an outline of the process and its modifications, and an account of the phenomena observed while the process is in operation. Illustrates and describes various converters. 7000 w. Jour Soc of Arts—July 8, 1898. Serial. 3 parts. No. 21520 each A.

Blast Furnaces.

Management of Blast Furnaces. E. S. Cook. Lecture delivered to third year students in metallurgy in the Schools of Mines and Chemistry, Columbia University, New York. Relates the writer's experience, discussing fluxing, fuel, and ores. 2500 w. Ir Trd Rev—July 21, 1898. Serial. 1st part. No. 21591.

Cast Iron.

See Mechanical Engineering, Shop & Foundry.

Iron Ore.

British Iron Ore Requirements and Sources of Supply. Part first describes the position of the United Kingdom, and countries of Europe in regard to the supply. 3000 w. Col Guard—July 8, 1898. Serial. 1st part. No. 21549 A.

The Oolitic Formation of German Lorraine. (Die Minettenformation Deutsch-Lothringens.) Dr. W Kohlmann. A general account of the geology of the region, with fine geological map, sections and borings. 7500 w. 3 plates. Stahl und Eisen—July 1, 1898. No. 21747 D.

Japan.

The Basis of the Japanese Iron Industry. (Die Grundlagen der Japanischen Eisenindustrie.) A review of the iron and manganese ore supplies of Japan, together with the fire clays and other materials. 1000 w. Stahl und Eisen—June 15, 1898. No. 21744 D.

The Raw Materials of the Japanese Iron Industry. Translated from *Stahl und Eisen*. Information of the iron-ore deposits, the manganese ores, and refractory materials. 600 w. Ir & Coal Trds Rev—June 24, 1898. No. 21332 A.

Rolling.

Difficulties in Rolling. William Hirst. Discusses some of the difficulties common to the roller's art, pointing out faults or errors that are the usual cause of trouble. Ill. 3700 w. Ir Age—June 30, 1898. No. 21241.

Rolling Mills.

Electric Power in Rolling Mills. Eugene B. Clark. From a topical discussion conducted by the Western Society of Engineers. Mentions some of the uses to which the power is applied, and the results. 1600 w. Ir Age—July 21, 1898. No. 21590.

Steel Plant.

The New Open Hearth Plant of the Carnegie Steel Company, Limited. Illustrated description of the main features of this fine plant. 2200 w. Ir Age—June 30, 1898. No. 21243.

The Steel and Iron Works of Trignac. (Les Aciéries, Haut Fourneaux et Forges de Trignac.) Hubert Bya. A full description of these important works, near St. Nazaire, France, with plates of details. 9000 w. 4 plates. Revue Universelle des Mines—June, 1898. No. 21-720 H.

Urals.

The Iron Industry of the Urals. G. Kamensky. Reviews the history of this industry, its immense resources, the treatment required for the ores, &c. 3000 w. Col Guard—July 1, 1898. No. 21459 A.

Works.

Our Iron and Steel Works in 1898. James M. Swank. Extracts from preface to the Fourteenth Edition of the Directory to the Iron and Steel Works of the United States, published by the American Iron & Steel Assn. 1800 w. K R Gaz—July 8, 1898. No. 21397.

MINING.

Deep Mines.

Hoisting Plant for Deep Mines. (Forderanlagen für Grosse Tiefen.) E. Tomson. A very full account of the plant at the Preussen mine at Dortmund, with detail drawings, computations and much valuable information. Four articles. 12000 w. 20 plates. Glückauf—June 4, 11, 18, 25, 1898. No. 21750 each B.

Steam Raising, Motive Power, and Accessory Winding Engines at a Westphalian Colliery. E. Tomson. From a communication to the jubilee meeting of the Liége Engs' Assn. Describes an installation of the Preussen Colliery, No. 1 pit. Ill. 2000 w. Col Guard—July 8, 1898. No. 21551 A.

Electric Pump.

Underground Electric Pump at the Anzin Colliery. M. Barry, and M. Baudot. From a communication to the Société de l'Industrie Minérale. Illustrated description of a pump installed at the Lambrecht pit of the Anzin Colliery. The distinguishing features are the use of the continuous current with a tension of 500 volts, and of a dynamo and motor with moderate speed. 3500 w. Col Guard—July 15, 1898. No. 21631 A.

High-Pressure Steam.

The Use of High-Pressure Steam at Collieries. Hugh Bramwell. From the Jour. of the British Soc. of Min. Students. Notes, recording experience gained as to the care necessary in adopting a high boiler pressure at collieries. 1600 w. Col Guard—July 1, 1898. No. 21455A.

Instruments.

The Pantograph and Planimeter. Charles E. Bowron. A description of some of the advantages attained by their use in the making of mine maps. 1000 w. Mines & Min—July, 1898. No. 21408 C.

Legislation.

Mining Legislation in Indiana. Robert Fisher. A history of its development and the improvement of the condition in the mines up to the present time. Statistics for 1897. 1500 w. Mines & Min—July, 1898. No. 21407 C.

Mine Legislation and Inspection in the Anthracite Coal Region of Pennsylvania. G. M. Williams. Address before the International Mining Congress at Salt Lake City. States the salient parts of the law, and the benefits derived, reviewing the legislation enforced and the duties of inspectors. 2700 w. Min & Sci Pr—July 23, 1898. No. 21686.

The Last Chance Decision. Important decision of the U. S. Supreme Court. Full text. 3800 w. Eng & Min Jour—July 16, 1898. Serial. 1st part. No. 21511.

Reforms.

Needed Reforms in Mining. James Inglis. Read at meeting of Sydney Chamber of Commerce. Calling attention to the need of a new mining law for Australia, and discussing the special points needing correction. 2500 w. Aust Min Stand—May 19, 1898. No. 21334 B.

Rescue Apparatus.

Comparative Experiments with the Neupert and Walcher-Gärtner Rescue Apparatus. R. Heller, in *Oesterreichische Zeitschrift für Berg- und Huttenwesen*. Experiments made to ascertain the effect on respiration and circulation by the wearing of the apparatus and whether any and what kind of pathogenic symptoms supervened. 1300 w. Col Guard—July 1, 1898. No. 21456 A.

Tunnel.

The Cowenhoven Adit Level. David William Brunton. Contributed to the British Inst. of Civ. Engs. Describes the conditions existing in the silver mines of the Aspen district, Colorado, which necessitated the construction of this tunnel, the difficulties overcome, method of construction, ventilation, means of communication, expense, &c. Ill. 6400 w. Col Guard—June 24, 1898. No. 21331 A.

MISCELLANY.

Alloys.

Experimental Researches on the Metallic

Alloys. (Recherches Expérimentales sur les Alliages Métalliques.) G. Charpy. Devoted especially to the white antifriction alloys, with much valuable information and many tables; the whole forming a part of the work of the Commission on Alloys. 10000 w. Bulletin de la Societe d'Encour—June, 1898. No. 21721 G.

Aluminum.

Aluminum as Fuel. Dr. H. Goldschmidt. From a paper read before the German Electro-chemical Society, Leipsic. Explains the process of using aluminum as a refining and heat producing agent, and the adaptation of the working method to the purpose in view. 1600 w. Am Mfr & Ir Wld—July 1, 1898. No. 21367.

Bitumens.

The Technology of California Bitumens. S. F. Peckham. Facts relating to this vast accumulation, showing them to be of value, and reporting investigations and conclusions. 40000 w. Jour Fr Inst—July, 1898. No. 21301 D.

Brass.

See Mechanical Engineering, Shop & Foundry.

Cuba.

Mineral Resources of Cuba. Raimundo Cabrera. Translated from the Spanish by Louis Edward Levy. A general statement of the great riches, almost unexplored, of this island, including asphaltum, copper, iron, manganese and gold. Discussion. 7000 w. Jour Fr Inst—July, 1898. No. 21300 D.

Explosives.

Modern High Explosives. Louis Y. Schermerhorn. Portion of a topical discussion before the Engs.' Club of Philadelphia. Defines the classes of explosives, their energy, effects, &c. 2500 w. Ir Age—July 28, 1898. No. 21667.

Ores.

The Concentration of Ores. A lecture by Prof. R. H. Richards, of the Massachusetts Institute of Technology, before the Society of Arts, Boston. Abstract. 1800. Mines & Min—July, 1898. No. 21412 C.

Persia.

The Mineral Resources of Persia. R. Helmhacker. Reports showing large mineral resources, but little developed. 2200 w. Eng & Min Jour—July 9, 1898. No. 21434.

Phosphate.

The Phosphate Deposits of Tennessee. J. B. Killebrew. The first paper deals with the subdevonian phosphates, reviewing their discovery, extent, and mining. 4200 w. Mfrs Rec—July 8, 1898. Serial. 1st part. No. 21391.

Slate.

The Slate Regions of Pennsylvania. Mansfield Merriman. Gives the general characteristics of the states of the five Pennsylvania regions, with other information. Ill. 4000 w. Stone—July, 1898. No. 21622 C.

Smelting.

Lead Smelting in the Joplin, Missouri, District. E. Hedburg. Early history and the different processes now in use. A description of the Scotch lead furnace, also the Lewis Bartlett process and system of making sublimed white lead as carried on at the works of the Picher Lead Co. Ill. 2200 w. Mines & Min—July, 1898. No. 21409 C.

MUNICIPAL ENGINEERING.

GAS SUPPLY.

Acetylene.

Acetylene and Its Modern Developments. Vivian B. Lewes. Read at Belfast meeting of the Incorporated Gas Inst. Considers the production, cost and utility of acetylene, discussing the generators, burners, dangers, &c., and its present standing. Discussion. 11400 w. Gas Wld—June 25, 1898. No. 21343 A.

Acetylene Gas Generators and the Essentials of Safety in their Construction and Use. J. Pemberton Stubbs. Read before the Incorporated Society of Inspectors of Weights and Measures. Part first is introductory dealing with the production of calcium carbide, and showing that with ordinary care little danger is risked in the use of acetylene. 2300 w. Engng—July 15, 1898. Serial. 1st part. No. 21638 A.

Apparatus for the Production of Acetylene Gas. From *Le Génie Civil.* Describes and illustrates two types, one having been in use for two years. 1200 w. Sci Am Sup—July 2, 1898. No. 21260.

Some Theoretical Aspects of Acetylene Manufacture. Calls attention to the great interest taken in this new illuminant, and the promising future awaiting it, considering briefly the chemical phenomena and reactions taking place during the decomposition of the carbide. 2700 w. Engr, Lond—June 24, 1898. No. 21327 A.

The Acetylene Gas Exhibition. General description of the exhibition now open at the Imperial Institute, London. 2200 w. Col Guard—July 1, 1898. No. 21460 A.

The Dangers of Acetylene. M. Ad. Bouvier. Read before the Société Technique du Gaz. Abstract, discussing the properties, risks and safeguards. 1400 w. Gas Wld—July 9, 1898. No. 21525 A.

Address.

President's Inaugural Address before the Incorporated Gas Institute, at Belfast, Ireland. James Stelfox. An interesting review of the progress of gas lighting, and of subjects important to the industry. 6800 w. Gas Wld—June 25, 1898. No. 21340 A.

Amendments.

The Necessity for Amendments in the Gas-Works Clauses Acts of 1847 and 1871. W. F. Cotton. Presented at Belfast meeting of the Incorporated Gas Inst. Calls attention to the particulars in which the defects of the acts work confusion and lead to litigation. 4400 w. Gas Wld—June 25, 1898. No. 21348 A.

Analysis.

Laboratory Notes on Gas Analysis. John T. Sheard. Describes a modification of Hempel's apparatus which is capable of giving quite exact results. 1200 w. Gas Engs' Mag—July 11, 1898. No. 21659 A.

Calcium Carbid.

The Calcium Carbid Industry. Editorial review of the remarkable activity displayed. 1300 w. Engng—July 15, 1898. No. 21637 A.

Cheap Gas.

The Cheapest Gas in the World. An interview with Mr. Isaac Carr, manager of the gasworks at Widnes, Eng., as to how this gas is produced. 2500 w. Gas Wld—July 16, 1898. No. 21647 A.

Fuel Gas.

The Cost of Fuel Gas, E. P. Reichhelm. On the value of this gas, showing that producer gas is often more expensive to use than illuminating gas. 800 w .Am Mach—June 30, 1898. No. 21247.

Incandescence.

Facts on the Theory of Incandescent Gaslight. Dr. G. P. Drossbach. From *Journal für Gasbeleuchtung und Wasserversorgung.* Gives experiments undertaken by the writer. 1200 w. Pro Age—July 1, 1898. No. 21274.

Two Incandescent Lights.—Gas v. Electric. J. H. Moxon. Suggestions for popularizing the incandescent gas burners. 1500 w. Gas Engs' Mag—July 11, 1898. No. 21658 A.

Meter Unions.

Standardizing of Meter Unions. Robert S. Carlow. Read at Belfast meeting of the Incorporated Gas Inst. A résumé of the reports and discussions of the North British Assn. Followed by discussion. 4000 w. Gas Wld—June 25, 1898. No. 21347 A.

Pintsch Gas.

The Manufacture of Pintsch Gas. Illustrates a typical plant installed at New Haven, Conn., for supplying the cars of the N. Y., N. H., and H. R. R. 1800 w. Sci Am—July 9, 1898. No. 21399.

Purifiers.

The Construction of and Mode of Working Purifiers. Henry Green. Read at Belfast meeting of the Incorporated Gas Inst. The paper is mainly devoted to a description of the purifiers of the Moor Lane station, Preston, and an account of their working. Discussion. Ill. 6600 w. Gas Wld—June 25, 1898. No. 21344 A.

Yeadon's Mechanical Purifying Machine. Illustrated description of the machine and its operation. 1600 w. Jour of Gas Lgt—July 19, 1898. No. 21671 A.

Retorts.

Inclined Retorts at Salford. S. Y. Shoubridge. Read at Belfast meeting of the Incorporated Gas Inst. An account of these retorts with reasons for the modifications introduced. Tables of comparative results, costs, etc., with other particulars. Discussion. Ill. 6000 w. Gas Wld—June 25, 1898. No. 21346 A.

The Brouwer-Rouget Coke-Conveyer and Retort-Charger. Illustrated description. 700 w. Jour Gas Lgt—June 21, 1868. No. 21483 A.

Valuation.

The Valuation of Gas Works for Assessment. William Newbigging. Read before the Belfast meeting of the Incorporated Gas Inst. Principally devoted to showing how faulty are the present methods. Discussion. 7000 w. Gas Wld—June 25, 1898. No. 21341 A.

Village Lighting.

Village Lighting: A Comparison. R. G. Shadbolt. Read at Belfast meeting of the Incorporated Gas Inst. Showing the effect on cost of electricity by using the oil engine, and its comparison with the price of gas; urging the same skill and economy in villages that is practiced in cities, thereby enabling the gas industry to successfully compete with electricity. Ill. 4000 w. Gas Wld—June 25, 1898. No. 21342 A.

Water Gas.

The Dellwik Method of Producing Water Gas. Carl Dellwik, in *Jernkontorets Annaler.* Illustrated description of this method, which claims to be sufficiently economical to meet the conditions of low cost. 1800 w. Ir & Coal Trds Rev—July 1, 1898. No. 21453 A.

Delwik's Water Gas. Abstract of a lecture recently delivered by the inventor before the Swedish Teknologförening at Stockholm. Ill. 1800 w. Ir Age—July 21, 1898. No. 21589.

SEWERAGE.

Cesspools.

Odorless Cesspool Cleaning. Illustrated description of methods and apparatus used by Supt. of Health, at Malden, Mass. 700 w. Eng Rec—July 9, 1898. No. 21419.

Irrigation.

The Irrigation Fields of Berlin and their Discharge Water. (Die Rieselfelder der Stadt Berlin und ihre Abwasser.) A discussion with professional opinions upon the nature of the drainage from the sewage irrigated farms near Berlin, with chemical analyses. 4000 w. Gesundheits-Ingenieur—June 15, 1898. No. 21765 D.

Nottingham, Eng.

The Sewerage of Nottingham, Eng. James H. Fuertes. Describes and illustrates a 900-acre sewage farm. 1200 w. Eng Rec—July 16, 1898. Serial. 1st part. No. 21505.

Pipe Joints.

Sewer Pipe Joints in England. John A. Turner. Illustrated description of various types. 2000 w. Brick—July, 1898, No. 21319.

Purification.

On the Use of Coke Breeze in Sewage Purification. John W. Alvord. Detailed review of the development of coarse grain filters, and experiments relating to them. Discussion and correspondence. 6000 w. Jour W Soc of Engs—June, 1898. No. 21438 D.

Sewage Disposal.

Soil Pollution from Careless Disposal of Sew-

age. F. A. Lyman, in the *Medical Age*. Showing the danger arising from this source and the great importance of securing pure air and pure water. 1300 w. San Rec—July 8, 1898. No. 21519 A.

Sewer Construction.

The Mechanical Plant of the Great Clichy Collecting Sewer. (Les Installations Mécanique du Grand Collecteur de Clichy.) R. Legouëz. Describing the various mechanical devices used in the construction of this great Paris sewer; including shields, hydraulic cylinders, conveyors, pumps, motors, &c., &c. 7500 w. Revue de Mécanique—May, 1898. No. 21727 H.

Sewers.

Carrying a Steel Pipe Sewer Across a Bridge at London, Ontario. Describes the carrying of a 36-in. main across the river Thames, at an elevation of 24-ft. above low water, at London, Ontario. Ill. 600 w. Eng News—July 14, 1898. No. 21487.

The Effective Prevention and Dissemination of Noxious Gases in Sewers. Frank Latham. On the proper means of sewer ventilation, so as to remove the gaseous effluvia in a manner that will least tend to vitiate the air. 1500 w. San Rec—July 15, 1898. Serial. 1st part. No. 21621 A.

The Sewerage System of Depew, N. Y. Illustrated description of details of sewers and chemical treatment works for sewage disposal. 1200 w. Eng Rec—July 9, 1898. No. 21418.

STREETS AND PAVEMENTS.

Guaranties.

Asphalt Paving Guaranties. Review of decision of New Jersey Court of Appeals upholding contracts for asphalt paving with a 5-year guaranty clause. 600 w. Eng Rec—July 23, 1898. No. 21611.

London.

London Improvements. Discusses the schemes for the widening of the Strand and other street improvements. 1600 w. Ill Car & Build—July 1, 1898. No. 21430 A.

Paving Materials.

Street Paving Materials. J. J. Bell. General review of the materials that have been used in various localities, with statement of the cost per sq. yd. of the pavements in use in Toronto, Can. 1200 w. Can Engr—July, 1898. No. 21567.

Roads.

Tar in Road Making. Extracts from paper of A. H. Campbell read at Edinburgh meeting of the Assn. of Municipal & County Engrs., in the use of tarred macadam in the construction of roadways. 1800 w. Gas Wld—July 9, 1898. No. 21526 A.

Street Improvements.

Rebuilding of Central Florence. From report of British Consul-General Chapman. Brief account of the project to clear out the more central part of the town and trace larger and more regular streets, and otherwise improve the locality. 1200 w. Arch, Lond—July 8, 1898. No. 21527 A.

WATER SUPPLY.

Bangor, Maine.

The Hydraulic Plant for the Bangor Water Works. Illustrated description of a 10,000,000-gal. pumping station driven by water power, in which unique arrangement of turbines was necessary to allow for tidal fluctuations. 2500 w. Eng Rec—July 2, 1898. No. 21308.

Early Methods.

Early Methods of Collecting, Storing, and Distributing Water. William R. Hill. Read at meeting of Am. Water Works Assn. Reviews the ancient works of various countries, showing advances made. 4000 w. Munic Engng—July, 1898. No. 21479 C.

Examination.

The Chemical and Bacteriological Examination of Water. Percy F. Frankland. Abstract of paper read at meeting of British Assn. of Water-Works Engs. Discusses the purification of water, and the importance of bacteriological examination. Discussion. 3500 w. Jour Gas Lgt—June 28, 1898. No. 21485 A.

Explosion.

The Cleveland Tunnel Explosion. An account of a gas explosion in a water-works tunnel, killing 11 men. 1000 w. Eng Rec—July 23, 1898. No. 21612.

Filtration.

Filtration at Elgin, Illinois. Illustrates and describes a very complete system. 600 w. Fire & Water—July 23, 1898. No. 21643.

Mechanical Filtration. W. P. Mason. Read at meeting of the Am. Water Works Assn. Notes on the experiments made at the Elmira filtering plant by order of the U. S. Courts. 1200 w. Munic Engng—July, 1898. No. 21482 C.

Water Filtration at Cardiff, Wales. Describes three open sand filters. 1200 w. Eng Rec—July 2, 1898. No. 21309.

Havana.

The Sanitary Regeneration of Havana. George M. Sternberg. Describes the sanitary condition of this city, and discusses the possibility of regeneration, considering that if placed in a satisfactory sanitary condition as regards its dwellings, sewers, and pavements, it would be practically immune from yellow fever. 4400 w. Century Mag—Aug., 1898. No. 21684 D.

Jersey City, N. J.

Water for Jersey City, N. J. Editorial showing the foolishness of the specifications adopted for works. 1100 w. Eng Rec—July 9, 1898. No. 21414.

New Works.

New Works for the Water Supply at Gosport. E. T. Hildred. Read at meeting of the British Assn. of Water Works Engs. Abstract. Description and discussion. 3500 w. Jour of Gas Lgt—June 21, 1898. No. 21484 A.

New York's Supply.

Greater New York's Water Supply. F. B.

Thurber. Calling attention to the need of additional supply in Brooklyn, and suggesting the Catskills as a source of supply, quoting from discussions of the subject. 3800 w. N Am Rev—July, 1898. No. 21291 D.

Rates.

An Unusual Suit Over Water Rates. Editorial review of a decision of the Massachusetts Supreme Court concerning the use of meters. 800 w. Eng Rec—July 16, 1898. No. 21500.

Liability for Unpaid Water Rates. Review of decision of Massachusetts Supreme Court defining liability of tenant for unpaid rates of previous tenants. 1300 w. Eng Rec—July 2, 1898. No. 21307.

Water Meters and Rates. John B. Heim. Read at meeting of the Am. Water Works Assn. Discusses the advantages of using meters, the rates, &c., giving illustrations from experience. 3300 w. Munic Engng—July, 1898. No. 21480 C.

Reservoirs.

Cleaning Reservoirs. Dow R. Gwinn. Read at meeting of the Am. Water Works Assn. Gives the writer's experience in this work. 1000 w. Munic Engng—July, 1898. No. 21481 C.

The Twin Lakes Reservoir, Colorado. W. P. Hardesty. Describes the great natural advantages, and the work necessary in adapting the site for the conservation of water supplies. 1100 w. Eng News—June 30, 1898. No. 21251.

Water Supply.

A Comparison between the Water Supply of Vienna and of Paris. (Einige Vergleichende Mittheilungen über die Wasserversorgungs-Verhältnisse in Wien und in Paris.) Carl Sykora. With interesting data concerning sources, reservoirs and distribution in the two cities. 4000 w. Zeitschr Oesterr Ing u Arch Ver—July 1, 1898. No. 21731 B.

Water Works.

Sources, Modes of Supply and Filtration of Public Water Supplies in the United States. Figures taken from a graduating thesis of Benjamin H. Flynn, compiled by him from the "Manual of American Water Works" for 1897. 1400 w. Eng News—July 7, 1898. No. 21386.

The St. Louis Water-Works. Editorial on proposal to prevent alienation of works except by popular vote. 700 w. Eng Rec—July 9, 1898. No. 21413.

MISCELLANY.

Fire Regulations.

Fire Resisting Construction. G. A. T. Middleton. A discussion of the regulations in force in London, both as regards general buildings and places of entertainment. 2500 w. Engineering Magazine—August, 1898. No. 21796 B.

RAILWAY AFFAIRS.

CONDUCTING TRANSPORTATION.

Accidents.

Train Accidents in the United States in June, 1898. Detailed list and classified summary, with comments. 3000 w. R R Gaz—July 22, 1898. No. 21599.

Blockade.

A Blockade on the New York, New Haven and Hartford. An account of the damage to the double-track bridge over the Housatonic River, five miles east of Bridgeport, and the management of trains during the blockade, which lasted 41 hours. 1400 w. R R Gaz—July 8, 1898. No. 21396.

Car Service.

Per Diem Car Service. Editorial discussion of Mr. Daly's scheme for the use of exchanged cars. 1200 w. R R Gaz—July 8, 1898. No. 21398.

Circus Train.

An American Circus Train in England. Instructions contained in a circular, issued by the Midland Railway of England, for the handling of the Barnum & Bailey circus train from Sheffield to Leeds. 1200 w. Ry Age—July 22, 1898. No. 21644.

Conventions.

The Work of the Railway Mechanical Conventions of 1898. Editorial discussion of the action to bring about a consolidation of the organizations, and the forces which are tending to unite the associations, with other features of the conventions. 2800 w. Eng News—June 30, 1898. No. 21252.

Grain Elevators.

Elevator System of the Illinois Central R. R. at New Orleans. Illustrates and describes the grain handling facilities, and the recent improvements. 1500 w. Ry & Engng Rev—July 23, 1898. No. 21646.

Mileage.

Car Mileage Records. A. O. Kittredge. Gives a brief survey of the practice of several companies. 2000 w. St Ry Jour—July, 1898. No. 21377 D.

Train Services.

The July Train Services. Charles Rous-Marten. Reviews the most prominent features of the July alterations in England from an engineering view-point, in relation to the progress or retrogression shown by the various railways. 2000 w. Engr, Lond—July 8, 1898. No. 21556 A.

The London and Liverpool Train Service. Editorial criticism of the service on the London and North Western Railway, with discussion of the situation. 1200 w. Engng—July 8, 1898. No. 21543 A.

Train Service in England. W. M. Acworth. States the condition of train service in England as compared with the United States and France, and the efforts being made to improve the English service. 1000 w. R R Gaz—July 8, 1898. No. 21392.

Union Pacific R. R.

Across Wyoming by the Union Pacific. W. P. H. Letter calling attention to the features of interest to an engineer. 4000 w. Eng News—June 30, 1898. No. 21253.

FINANCIAL.

Earnings.

Railroad Earnings Still Favorable. Report for June, 1898, with comparative tables. 2800 w. Bradstreet's—July 16, 1898. No. 21496.

LEGAL.

Interstate Commerce.

The Railroads and the Interstate Commerce Law. Address of M. E. Ingalls at the convention of the Railroad Commissioners at Washington. Discusses the difficulties and the changes in legislation needed. 3800 w. Ir Age—July 7, 1898. No. 21382.

Swiss Railroads.

The Nationalization of Swiss Railroads. W. M. Acworth. Extracts from a paper written for the *Economic Journal*. Gives an outline of the organization for the government of railroads, and discusses the prospects 1300 w. R R Gaz—July 8, 1898. No. 21394.

MOTIVE POWER AND EQUIPMENT.

Air-Brake Hose.

Specifications for Air-Brake Hose. Report of committee to Master Car Builders' Assn. Discusses the manufacture of hose, the causes of weakness, giving recommended specifications and tests. Ill. 3000 w. Am Eng & R R Jour—July, 1898. No. 21352 C.

The Unwinding Test for Air-Brake Hose. G. P. Campbell. Report of test made, with some facts concerning rubber. Also a letter from a maker. 1500 w. R R Gaz—July 22, 1898. No. 21598.

American Railways.

Railways in America. (Les Chemins de Fer en Amerique.) P. Pasquier. A comparison, mainly as regards speed, between American and European railways. 6000 w. Revue Universelle des Mines—June, 1898. No. 21719 H.

Bearings.

Center Bearings or Side Bearings. Extracts from an interesting discussion at the May meeting of the Western Railway Club. 2000 w. R R Gaz—July 15, 1898. No. 21492.

Car Axles.

An Axle for Heavy Cars. Extracts from letter of E. D. Nelson, presented at the M. C. B. convention, on this subject. 900 w. R R Gaz—July 1, 1898. No. 21267.

Car Lighting.

Acetylene and Mixed Gas Plants for Lighting Railway Cars. (Acetylen-und Mischgasanstalten für Beleuchtung der Eisenbahnwagen.) A paper by Herr Bork describing a plant for the production of calcium carbide, and acetylene in connection with oil gas, the whole forming a complete car-lighting plant. 4500 w. 1 plate. Glaser's Annalen—June 15, 1898. No. 21740 D.

Electric Power.

The Application of Electricity to Steam Railroads. D. W. Brangs. Read before the Am. Ry. Master Mechs. Assn. Reviews the various methods by which electricity can be applied for heavy railroad work, and its advantages. 1800 w. Elec Rev, N. Y.—July 20, 1898. No. 21571.

Guard Communication.

Electrical Passenger and Guard Communication. Illustrated description of arrangements employed on the Great Eastern Railway of England. 700 w. Transport—July 8, 1898. No. 21533 A.

Railway Passenger Communication. Report of the committee appointed by the British Board of Trade, to consider points relating to the means of communication between passengers and guards on railway trains. 3200 w. Elec Engr, Lond—July 15, 1898. No. 21652 A.

Locomotives.

A Suggestion for the Improvement of the Locomotive. George S. Strong. Gives the writer's ideas in regard to American practice and its limitations, with a suggestion regarding the use of feed-water heaters for locomotives. 1000 w. R R Gaz—July 22, 1898. No. 21597.

Consolidation Locomotive for Southern Railway. Illustrated description with dimensions. 700 w. Ry & Engng Rev—July 16, 1898. No. 21566.

Eight-Wheel Passenger Locomotives—Cleveland, Cincinnati, Chicago & St. Louis Railway. Illustrated description with principal dimensions. 1000 w. R R Gaz—July 15, 1898. No. 21491.

Geared Locomotives on the Mount Tamalpais Railway. Illustrated description of a 30-ton engine of the central shaft class, designed by Charles Heisler, and running on a scenic railway in California. 1300 w. Sci Am—July 16, 1898. No. 21473.

London and Southwestern Express Locomotive of 1856. Herbert T. Walker. Illustrates and describes an old engine designed by Joseph Beattie. 900 w. R R Gaz—July 29, 1898. No. 21687.

New High-Speed Compound Locomotives. (Les Nouvelles Locomotives Compound à Grand Vitesse.) An illustrated account of the fine new four-cylinder compound engines, constructed for the Northern Railway of France. 2500 w. Génie Civil—July 9, 1898. 1 plate. No. 21716 D.

Old Locomotives, Dublin and Kingstown Railway. Illustrated description of the Jupiter, one of the standard engines of this line, constructed in 1840. 450 w. Engr, Lond—June 24, 1898. No. 21329 A.

Ten-Wheel Passenger Locomotives; Grand Trunk Ry. Illustration, description, and principal dimensions. 500 w. Eng News—July 28, 1898. No. 21693.

The New North British Express Engine. Charles Rous-Marten. Information relating to the new "729" class of locomotives with report of tests of actual working made by the writer. 1600 w. Engr, Lond—July 1, 1898. No. 21468 A.

Wiredrawing.

The Wiredrawing of Steam in Locomotives. (Die Drosselung des Dampfes bei Lokomotiven.) A discussion, by Inspector Leitzmann, of the throttling action of the locomotive valve gear at early cut-off, illustrated by diagrams. 3500 w. Glaser's Annalen—June 15, 1898. No. 21741 D.

NEW PROJECTS.

Cuba.

The Railroads of Cuba. A sketch map with information from various sources. 900 w. R R Gaz—July 8, 1898. No. 21395.

Newfoundland.

Newfoundland's Railway Completed. An account of the accomplishment of an undertaking which unites all of England's possessions in this quarter of the globe. 900 w. Sci Am Sup—July 23, 1898. No. 21588.

PERMANENT WAY AND FIXTURES.

Complicated Tracks.

Track Elevation and Depression at the 16th St. Crossing, Chicago. This section, which is probably the most complicated system of grade crossings in Chicago, is illustrated and described. 1800 w. Eng News—July 14, 1898. No. 21488.

Cross Ties.

Comparative Tests of Metallic Cross Ties. (Essais Comparatifs de Traverses Métalliques.) A very full report of the results of tests of various kinds of metallic ties on the Netherlands State Railways from 1881 to 1898, with plate showing the forms tested. 6000 w. 1 plate. La Revue Technique—July 10, 1898. No. 21709 D.

Freight Yard.

A Novel City Freight Yard. Illustrates the freight yard of the Harlem Transfer Co., 135th St., New York City. It was designed by Walter G. Berg, and presents many interesting features. 1000 w. R R Gaz—July 29, 1898. No. 21689.

Interlocking.

Pneumatic Interlocking at Exchange Street, Buffalo. Describes a plant for the N. Y. C. & H. R. R. R., containing 25 switches and 33 signals, in which all the functions are performed by compressed air. Ill. 1500 w. R R Gaz—July 8, 1898. No. 21393.

Railway Curves.

On the Relation Between the Radii of Railway Curves and the Wheel-Bases of Vehicles and locomotives. A. Hallbauer. Translated from the *Organ für die Fortschritte des Eisenbahnwesens*. Mathematical. 900 w. Ind Engng—May 28, 1898. No. 21380 D.

Sanding.

Track Sanding Arrangement. Illustrates a new and exceedingly simple design which is not patented. 700 w. R R Gaz—July 15, 1898. No. 21493.

Signals.

Electric Block Signals on the Boston and Albany. George W. Blodgett. Illustrated description of signal apparatus used, with discussion of systems and their operation, and showing that for some purposes and conditions, wire circuits can be used to better advantage than rail circuits. 3300 w. R R Gaz—July 22, 1898. No. 21600.

Improvements in Track Circuit Controlling Devices for Electrically Controlled Block Signals. R. J. Hewett. Considers improvements which provide a track circuit arrangement for actuating track relays at both ends of the track circuit. 1600 w. Ry & Engng Rev—July 16, 1898. No. 21565.

Uniformity and Consistency in the Use of Fixed Signals. Editorial on the recent address of F. A. Delano at Purdue University upon the use of railway signals. 1300 w. R R Gaz—July 29, 1898. No. 21692.

Station.

The New Paris Station of the Paris, Lyons, and Mediterranean Railway. Plans and sections of the work, with description. 2200 w. Engng—July 1, 1898. No. 21461 A.

The New Railroad Station at Dresden. From the *Illustrirte Zeitung*. Brief illustrated description. 800 w. Sci Am Sup—July 2, 1898. No. 21262.

STREET AND ELECTRIC TRAMWAYS.

Accounting.

Some Graphical Diagrams Used in the Operating and Accounting Departments. Treats of the application of graphical charts to railway records. 4000 w. St Ry Rev—July 15, 1898. No. 21516 C.

Alternating Currents.

The Application of Alternating Currents to Electric Traction. Chas. Henry Davis and Howard C. Forbes. A discussion of the economic advantages to be gained by the use of alternating currents, and the methods of transforming and controlling them. Part I. 3500 w. Engineering Magazine, August, 1898. No. 21799. B.

Batteries.

Storage Batteries. Interesting information relating to storage batteries and their efficiency. Ill. 2000 w. St Ry Rev—July 15, 1898. No. 21517 C.

Storage Battery Railroading. E. R. Gilbert. Considers the advantages and disadvantages of this system in comparison with other means of propulsion. 1800 w. St Ry Rev—July 15, 1898. No. 21518 C.

Brooklyn Bridge.

Surface and Elevated Cars on the New York and Brooklyn Bridge. Presents the situation, giving facts regarding the decrease in revenue, as the results of running the electric surface

cars, and the elevated railroad cars. 2000 w. R R Gaz—July 1, 1898. No. 21268.

Circuits.

The Overhead Line and Ground Return Circuit of Electric Street Railways. David Pepper, Jr. Reviews the important points in construction, and the progress made. 3600 w. Jour Fr Inst—July, 1898. No. 21302 D.

Controller.

The Henry "Regenerative" Controller for Electric Cars. John C. Henry. Presents the advantages claimed for this new system. 2000 w. Elec Eng, N. Y.—July 21, 1898. No. 21575.

Corea.

An Electric Railway in Corea. H. Collbran. A letter giving information concerning a street railway being constructed in Seoul, the capital city of Corea. Ill. 600 w. Ry Age—July 22, 1898. No. 21645.

Duisburg.

An illustrated description of the electric trolley road between Duisburg and Düsseldorf, with profile of the route and photographs of the trolley drawbridges. 2000 w. Ill. Zeitschr für Klein und Strassenbahnen—July 1, 1898. No. 21775 D.

Electric Traction.

Electric Railway System of the Meadville Traction Company. Brief illustrated description of a road in Pennsylvania, constructed according to the latest methods. 900 w. St Ry Jour—July, 1898. No. 21375 D.

The Hull Electric Railway. F. C. Armstrong. Illustrates and describes a branch road in Canada, recently equipped electrically. It has a considerable freight business in hauling lumber, grain, &c. 1800 w. St Ry Jour—July, 1898. No. 21374 D.

The System of the Schuylkill Valley Traction Company, Norristown, Pa. Map and illustrations of this line which passes through historic and very picturesque territory. 1500 w. St Ry Jour—July, 1898. No. 21376 D.

Elevated Road.

The Electric City Railway in Berlin. (Die Elektrische Stadtbahn in Berlin.) M. Foerster. A general description of the electric elevated railway in Berlin, with many illustrations of the structure and stations. 3000 w. Mitt des Ver f d Förd des Local- u Strassenbahnwesens—June, 1898. No. 21773 E.

Feeders.

Underground Feeders for Electric Traction. Charles E. Morris. Refers briefly to various methods adopted and their advantages and disadvantages. Ill. 1000 w. Ry Wld—July 7, 1898. No. 21618 A.

Franchises.

Relation of Cities and Towns to Street Railway Companies. L. S. Rowe. Comments on the recent report of the special committee appointed by the Governor of Massachusetts to investigate the relations between cities and towns and street-railway companies. 2200 w. An of Am Acad—July, 1898. No. 21558 G.

Goods Traffic.

The Unconscious Ownership of an Important Key. W. T. Bonner. Read at meeting of the Can. Elec. Assn. A plea for the introduction of goods traffic on our suburban railways, with discussion. Ill. 6600 w. Can Elec News—July, 1898. No. 21563.

Halifax.

Halifax Corporation Electric Tramways. Illustrated detailed description. 3000 w. Ry Wld—July 7, 1898. No. 21617 A.

Magnetic Disturbances.

The Disturbance of Magnetic Observatories by Electric Railways. (Ueber die Störungen Magnetischer Observatorien durch Electrische Bahnen) W. v. Bezold. Refers especially to the experience of the magnetic observatory at Potsdam, and shows that the permissible distance for electric railways is too close, also that position as well as distance should be considered. 2000 w. Elektrotech Zeitschr—June 16, 1898. No. 21754 B.

Manhattan Transit.

The Immediate Betterment of Manhattan Transit. O. F. Nichols. Proposes a system for the betterment of the facilities of the Manhattan Elevated Railway. Ill. 4000 w. R R Gaz—July 1, 1898. No. 21266.

Mountain Railway.

A Proposed Mountain Railroad for the Tyrol. From the *Illustrirte Zeitung*. An account of the plans being considered for an electric railroad from Gossensass to Amthorspitz, which commands an extensive and very beautiful view. 300 w. Sci Am Sup—July 16, 1898. No. 21477.

The Zermatt-Gornergrat Mountain Railway. Brief description of an interesting and instructive railway undertaking in Southern Switzerland. Ill. 1300 w. St Ry Rev—July 15, 1898. No. 21515 C.

The Zermatt-Gornergrat Electric Rack Railway. Abstract from article in *Le Génie Civil* describing this road. 1200 w. Eng News—June 30, 1898. No. 21255.

N. Y. City Railroads.

The Motive Power of the City Railroads of New York. H. G. Prout. From the *N. Y. Times*. Discusses the peculiar difficulties to be met in this city, and the steps being taken. 1800 w. Ir Age—July 28, 1898. No. 21668.

Open Cars.

Guards for Open Cars. Illustrated description of various devices in use. 1800 w. St Ry Rev—July 15, 1898. No. 21514 C.

Passenger Capacity.

A Plan to Increase the Passenger Capacity of the Wannsee Railway. (Ein Vorschlag zur Verbesserung der Verkehrsverhältnisse auf der Wannseebahn.) A discussion of the various methods proposed to provide for the rapid increase in travel on an electric road. 2500 w. Deutsche Zeitschr f Elektrotech—June 15, 1898. No. 21766 H.

Pittsburg, Pa.

Notes from the Field—Electricity on the

Pittsburg Street Railways. C. B. Fairchild. Part first is a description of the plant and equipment of the Consolidated Traction Company. 3000 w. Elec Eng, N. Y.—July 21, 1898. No. 21574.

Power.

Power Transmission and Distribution for Railway Work. Ernst J. Berg. Explains the method of control of potential in the converter station, discussing its effects on the operation in general. 4300 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21283 D.

Rapid Transit.

Some Phases of the Rapid Transit Problem. Albert H. Armstrong. Discusses various methods of train acceleration to determine the methods of running with the least expenditure of energy. 4200 w. Trans of Am Inst of Elec Engs—May, 1898. No. 21281 D.

Storage Battery.

An Electric Railway Storage Battery Plant. An illustrated description of the storage battery plant of the Buffalo Railway Company. 1000 w. Am Elect'n—July, 1898. No. 21368.

Stettin.

The Electric Street Railway at Stettin. (Elektrische Strassenbahn Stettin.) A fully illustrated description of the new electric tramway system recently installed in the capital of Pomerania. 4000 w. Ill. Zeitschr für Klein-und Strassenbahnen—June 16, 1898. No. 21774 D.

Underground.

The New Underground Railway in London. (Le Nouveau Chemin de Fer Souterrain de Londres.) An account, from a French point of view, of the Central London Railway, with plan of the route and a plate showing arrangement of the power plant and construction of the electric locomotives. 3500 w. 1 plate. Le Génie Civil—June 25, 1898. No. 21712 D.

The Waterloo and City Railway. An account of the formal inauguration of the line though not yet open for public traffic. 1800 w. Transport—July 15, 1898. No. 21661 A.

Waterloo and City Railway. Brief account of this deep-tunnel railway recently inaugurated. 2300 w. Engng—July 8, 1898. No. 21544 A.

NEW CATALOGUES AND TRADE PUBLICATIONS.

These catalogues may be had free of charge on application to the firms issuing them.
Please mention The Engineering Magazine when you write.

Clarke Chapman & Co., Ltd., Gateshead-on-Tyne, England.=Illustrated catalogues (*a*) of pumping machinery for boiler feeding, hydraulic and mining work, fully coded with tables of capacities, floor space, etc.; (*b*) of windlasses and hoisting machinery for ships, fully coded with statements of admiralty requirements, Lloyds and Bureau Veritas rules, and tables of anchors and chains.

Charles Clifford & Son, Ltd., Birmingham, England.=(*a*) Price list of copper, brass, and yellow metal in rods, wire tubes or sheet form, with tables of weights and gauges; (*b*) Large sheet of designs for ornamental tubing.

Alfred Herbert, Ltd., Coventry, England.=Illustrated catalogue and price list of machine tools, milling machines, cutter grinders, sensitive drills, capstan lathes, and special machinery for cycle manufacture. Well printed and fully illustrated.

John Wallis Titt, Woodcock Works, Warminster, Wilts, England.=Catalogue of wind engines and pumps. Prices and dimensions are invariably given and some useful notes on wind power and how to utilize it are appended.

Cash Robinson & Co., Woodville Electrical Works, Burton-on-Trent, England.=Price list of "Bristol" dynamos.

Sam. H. Rawley, Swadlingcote, Burton-on-Trent, England.=(*a*) Illustrated price list of sinks, basins and other sanitary appliances; (*b*) Several page price lists of railway lavatories and similar fittings.

The Ebbw Vale Steel, Iron & Coal Co., Ltd., Ebbw Vale, Mon., England.=Catalogue of steel springs for railway trucks, locomotives, and wagon buffing. Each design illustrated.

Tinker & Co., Globe Boiler Works, Dunkinfield, England.=Circular with illustrations of steel, Lancashire, Cornish and multitubular boilers.

Wm. Singleton, Newland Works, Lincoln, England.=Price list of waterproof wagon covers, jute stack sheets and horse clothing.

W. H. Bailey & Co., Salford, Manchester, England.=Circular describing the "Full-Bore" reducing valve for steam-air or water.

Thomas Perry & Son., Ltd., Highfield Works, Bilston, England.=Illustrated price list of safes, strong room doors, etc.

The Longford Wire, Iron and Steel Co., Warrington, England.=Illustrated catalogue of galvanized wire spring mattresses and bedsteads, seats and backs for railway carriages and wire cycle saddles, with prices, list of users and testimonials.

Baldwin Locomotive Works, Philadelphia, Pa., U. S. A.=Record of recent construction, No. 6. Pamphlet containing handsome illustrations of locomotives of all sorts recently built for railways in North and South America, as well as Europe, Asia, and Africa.

Baldwin Locomotive Works, Philadelphia, Pa., and Westinghouse Electric and Manufacturing Co., Pittsburg, Pa., U. S. A.=Beautifully printed and illustrated pamphlet showing the electric mining locomotives for underground haulage.

Buffalo Forge Company, Buffalo, New York, U. S. A.=Folder giving illustrations and description of the Buffalo Automatic Engines, both vertical and horizontal, single and double.

Westinghouse Electric and Manufacturing Co., Pittsburg, Pa., U. S. A.=Electricity for Machine Driving; a handsome pamphlet with numerous illustrations showing the advantages to be secured by the use of the electric current, instead of long lines of belting and shafting, for the transmission of power; many applications of the Tesla polyphase motors are shown.

John A. Roebling's Sons Company, Trenton, New Jersey, U. S. A.=Catalogue and price list of wire rope, and wire-rope fastenings, iron, copper, brass and steel wire, hard copper telephone wire, bi-metallic wire, copper wire and cables for electrical purposes; with descriptive notes on cableways and tramways, suspension bridges, transmission of power by wire rope, inclined planes, and wire rope haulages.

The Ingersoll-Sergeant Drill Co., New York.=Catalogue No. 32. Devoted to compressors for all kinds of service, with many illustrations of straight-line, half-duplex, duplex, and compound air-compressors, arranged to be driven by various sources of power. Many valuable tables of useful information are given.

The Consolidated Safety Valve Company, New York.=Catalogue of Richardson and Ashcroft "Pop" safety valves for use on stationary, marine, locomotive, and portable boilers. Illustrations of the various types are given, and numerous testimonials from extensive users.

The Cincinnati Corrugating Co., Piqua, Ohio, U. S. A.=Catalogues (*a*) of corrugated steel arches for use in fire-proof building construction; (*b*) describing corrugated sheet metal roofing, with the improved edge corrugation, insuring tight joints.

Sprague Electric Company, New York.=Handsomely illustrated catalogues (*a*) of junction boxes for electric conduits; (*b*) of Lundell slow-speed electric motors; (*c*) of Lundell fan motors.

R. Hoe & Co., New York.=Pamphlet showing the improved printing presses used in the United States Government printing office, together with a long list of users of large Hoe presses all over the world.

SEPTEMBER, 1898

GENERAL LIBRARY
UNIV. OF MICH.
1 SEP 1898

THE ENGINEERING MAGAZINE

AN INDUSTRIAL REVIEW

EDITED BY JOHN R. DUNLAP
CHARLES B. GOING AND H. HARRISON SUPLEE.

THE ESSENTIAL ELEMENTS OF MODERN SEA POWER—
An Authoritative Review of England's Naval Programme. **Vice-Admiral P. H. Colomb, R. N.** 889
ENGINEERING LESSONS FROM THE HISPANO-AMERICAN WAR—
Mechanical Supremacy the Vital Factor in Military Success. **Hiram Stevens Maxim.** 899
EUROPEAN AND AMERICAN BRIDGE CONSTRUCTION—
The Extension of Modern Methods and Materials to Wide Spans. **Gustav Lindenthal.** 905
THE COMPARATIVE COST OF STEAM AND WATER POWER—
Practical Results Based upon Recent Experience. **William O. Webber.** 922
THE UNDERGROUND RAILWAYS OF LONDON—
The Development of Rapid Transit in the Metropolis. **Frederick E. Cooper.** 928
SOME COMPARATIVE POINTS OF INTERNATIONAL PATENT LAW—
Important Features in the Practice of Leading Nations. **J. Sinclair Fairfax.** 952
BACTERIAL PROCESSES OF SEWAGE PURIFICATION—
The Conversion of Organic Wastes into Harmless Effluents. **Rudolph Hering.** 960
THE APPLICATION OF ALTERNATING CURRENTS TO ELECTRIC TRACTION—
Local Power Stations Compared with Distant Natural Sources. **C. H. Davis and H. C. Forbes.** 974
THE BAKU PETROLEUM DISTRICT OF RUSSIA—
A Visit to the Oil Fields of South-Eastern Europe. **David A. Louis.** 986
EFFECTIVE METHODS OF FINDING AND KEEPING SHOP COSTS—
The System of an Extensive Electric-Manufacturing Company. **Henry Roland.** 1000

FOR INTRODUCTION TO AUTHORS, SEE PAGE 5.

REVIEW OF THE ENGINEERING PRESS.

The American Press, 1017 The British Press, 1025 The Continental Press, 1033

THE ENGINEERING INDEX.

With Descriptive Notes Clearly Indicating the Character and Purpose of Current Leading Articles in the Technical Press of the United States, Great Britain, and the Continent.

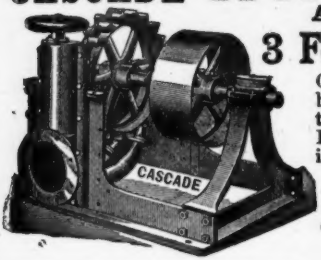
ARCHITECTURE AND BUILDING, - 1043
CIVIL ENGINEERING, - - - - 1044
ECONOMICS AND INDUSTRY, - - - 1047
ELECTRICAL ENGINEERING, - - - 1048
MARINE ENGINEERING, - - - - 1054
MECHANICAL ENGINEERING, - - 1055
MILITARY ENGINEERING, - - - - 1059
MINING AND METALLURGY, - - - 1060
MUNICIPAL ENGINEERING, - - - 1064
RAILWAY AFFAIRS, - - - - - - 1067
STREET AND ELECTRIC TRAMWAYS, - 1069

30 Cents a Number—$3.00 a Year.

PUBLICATION OFFICES, 120-122 LIBERTY ST., NEW YORK.
222-225 STRAND, LONDON, W. C.

MONTREAL 366 St. James St. | MELBOURNE Sun Buildings. | JOHANNESBURG Goodman & Co. | CAPETOWN 33 Loop Street. | CALCUTTA Thacker, Spink & Co. | YOKOHAMA Kelly & Walsh, Ltd.
PARIS 22 Rue de la Banque. | ST. PETERSBURG 14 Nevsky Prospect. | BERLIN 5 Unter den Linden. | VIENNA I., Karntnerstrasse 34. | ROME 307 Corso.

TURBINE AND CASCADE WATER WHEELS



Adapted to all Heads from

3 Feet to 2000 Feet.

Our experience of 34 YEARS building Water Wheels enables us to suit every requirement of Water Power Plants. We guarantee satisfaction.

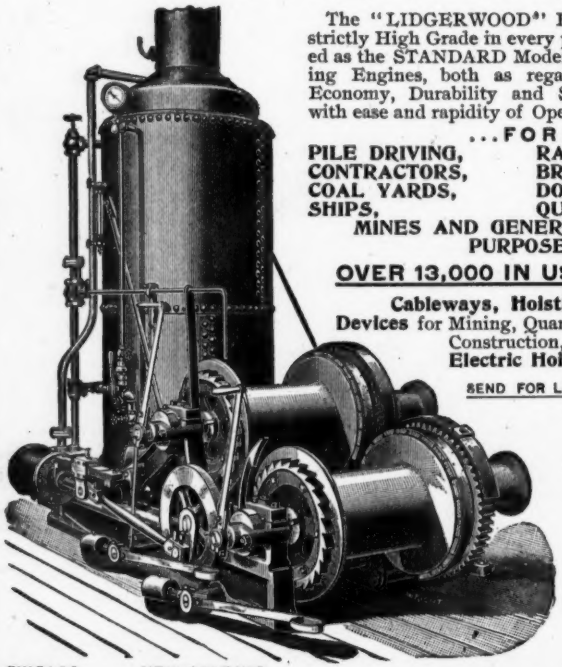
Send for a Pamphlet of either Wheel and write full particulars.

JAMES LEFFEL & CO.,
SPRINGFIELD, OHIO, U.S.A.

LIDGERWOOD
HOISTING ENGINES

Built to gauge on the Duplicate Part System. Quick Delivery Assured.

STANDARD FOR QUALITY AND DUTY.



The "LIDGERWOOD" Hoisting Engines are strictly High Grade in every particular and accepted as the STANDARD Modern High Speed Hoisting Engines, both as regards High Duty and Economy, Durability and Simplicity, combined with ease and rapidity of Operation.

...FOR...

PILE DRIVING, RAILROADS,
CONTRACTORS, BRIDGE BUILDERS,
COAL YARDS, DOCKS,
SHIPS, QUARRIES,
MINES AND GENERAL HOISTING PURPOSES.

OVER 13,000 IN USE.

Cableways, Hoisting and Conveying Devices for Mining, Quarrying, Logging, Dam Construction, etc. Steam and **Electric Hoists.**

SEND FOR LATEST CATALOGUE.

LIDGERWOOD MAN'F'G CO.,

CHICAGO, NEW ORLEANS,
BOSTON, PORTLAND, Ore.,
PHILADELPHIA, CLEVELAND, O.

96 LIBERTY STREET, NEW YORK.

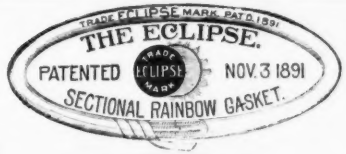
Copyrighted, 1898, by John R. Dunlap. Entered at the New York Post Office as second-class mail matter.

3/8 inch for Pipe Unions.

1/2 inch for Hand Holes.

5/8 inch for Regular Size.

3/4 inch for Large Size.

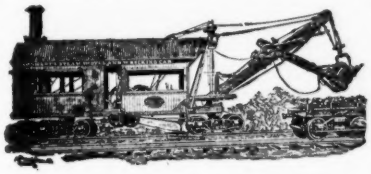


For
Hand Holes
and
Man Holes.

Write for Catalogues.

Facsimile of a 6-inch section of Eclipse Gasket, showing name and trade mark imbedded.

PEERLESS RUBBER MFG. CO., 16 WARREN STREET, NEW YORK.
16-24 Woodward Ave., Detroit, Mich. 202-210 So. Water St., Chicago, Ill.
17-19 Beale St., and 18-24 Main St., San Francisco, Cal.



THE MARION STEAM SHOVEL CO.

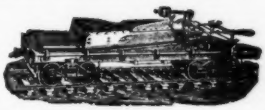
MARION, OHIO,

Manufacturers of a full line of

Steam Shovels, Ballast Unloaders, Dredgers and Ditchers,

SUITABLE FOR ALL CLASSES OF WORK.

Our machinery is in use in all parts of the United States and Canada, and in many foreign countries. Results are what purchasers are looking for. Our representations and statements are all conservative, and our machinery will do more than we claim for it in all cases under fair circumstances. All correspondence cheerfully answered. Write us for particulars regarding machinery suitable to your needs, and for illustrated catalogue. Address **The Marion Steam Shovel Co.,** **No. 607 W. Center Street, MARION, OHIO.**



COLD METAL SAWING MACHINES.

Q & C SHOP SAWS AND SAW BLADES.

QUICK TRIP JACKS. **SELF-FEEDING RAIL DRILLS.**

SEND FOR 1898 CATALOGUE.

THE BUCYRUS COMPANY,

DESIGNERS AND BUILDERS OF

Dredges, Steam Shovels, Excavating Machinery, Steam, Electric, and Locomotive Cranes, Centrifugal Pumps, with Simple, Compound or Triple Expansion Engines, Pile Drivers, Wrecking Cars, Placer Mining Machines.

SOUTH MILWAUKEE, WIS.

AIR COMPRESSORS

For every application of compressed air power.

COMPRESSED AIR TOOLS and APPLIANCES,
CLAYTON AIR LIFT PUMPING SYSTEM.

Clayton Air Compressor Works,

Complete catalogue sent upon application.

26 Cortlandt Street, New York.

Please mention The Engineering Magazine when you write.

Essential Features

which our Corrugated Perforated Metallic Lath possess—A rigidity which is lacking in the wire and expanded metal—The perforations large enough to give a positive clinch to the mortar—No stretching or stiffening for fastening and only ordinary nails required in its application—Cheaper than all others.

For special circular and prices write

THE CINCINNATI CORRUGATING CO.,

BOX 383, PIQUA, OHIO.

"KEYSTONE" OPEN LINK.

OPEN.

IT IS THE ONLY OPEN LINK ON THE MARKET THAT IS

DROP FORGED FROM BAR STEEL.

FOR STRENGTH, DURABILITY AND SIMPLICITY IT STANDS WITHOUT A RIVAL.

Sizes from ¼ in. to ¾ in.

KEPT IN STOCK.

STANDARD Wrenches, Hoist Hooks, Eye Bolts, Shafting Collars, Machine Handles, Thumb Nuts, Thumb Screws, Rope Sockets and Swivels, Fence Ornaments, Bicycle Forgings, &c.

Send for Catalogue and Discounts

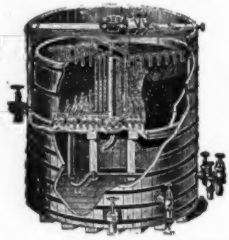
SPECIAL FORGINGS TO ORDER.

KEYSTONE DROP FORGE CO.,

20th and Clearfield Sts., PHILADELPHIA, PA.

CLOSED.

Gravity and Pressure Filters



CONSTRUCTED UNDER THE

Jewell, Warren and Hyatt Patents.

THE ACKNOWLEDGED STANDARD OF MECHANICAL FILTRATION.

Adopted by over 200 Cities and Towns in the United States.

Highest Efficiency. - Lowest Price.

NEW YORK FILTER MFG. CO, 26 CORTLANDT ST., NEW YORK. 220 DEVONSHIRE ST., BOSTON.

O. H. JEWELL FILTER CO, 40-42 W. QUINCY ST., CHICAGO.

Storage Batteries for Light and Power Plants.

OVER 70,000 H. P. HOURS ARE STORED DAILY IN CHLORIDE ACCUMULATORS.

THE ELECTRIC STORAGE BATTERY CO.,

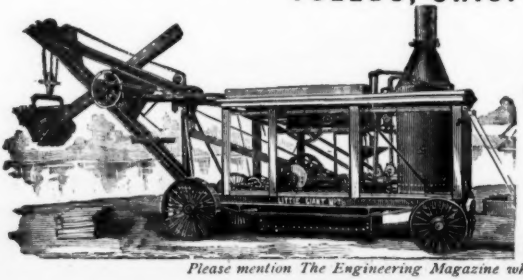
DREXEL BLDG., - - - - - - PHILA., PA.

SALES OFFICES:

NEW YORK, 20 and 22 Broad St. BALTIMORE, Equitable Bldg., BOSTON, 60 State St. CHICAGO, 1424 Marquette Bldg. CLEVELAND, O., 914, New England Bldg. CANADA, The Canadian General Electric Co., Limited, Toronto.

VULCAN IRON WORKS,

TOLEDO, OHIO.



STEAM SHOVELS.

Our "Little Giant."

SEND FOR CATALOGUE.

See next issue of this Magazine

THE PUBLISHER'S ANNOUNCEMENT.

Subscriptions:—$3.00 (or 12s. 6d.) a year, in advance. Booksellers and Postmasters receive subscriptions. Subscribers may remit in Post Office or express money orders, or in bank checks, drafts, or registered letters, made payable to "THE ENGINEERING MAGAZINE." Money in letters is at sender's risk.

Special Notice:—The date to which each subscription has been paid appears, with the address, on the wrapper enclosing each number of the Magazine. The publisher must be notified by letter when a subscriber wishes his Magazine discontinued. All arrearages must be paid.

Bound Volumes:—Containing the numbers for six months, in half Morocco, $3.00; half Russia, $2.75; half American seal, $2.75; full sheep, $2.75; cloth, $2.50. Back numbers will be exchanged, if in good condition, for corresponding bound volumes in half Morocco for $1 50; half Russia, $1.25; half American seal, $1.25; full sheep, $1.25; cloth, $1.00 per volume (six numbers); subscribers paying charges both ways. Postage on each volume 39 cents. All packages of numbers sent for binding should be marked with owner's name. Volumes end with March and September numbers.

Advertising:—The rates for advertising will be quoted on application.

{ Cable address: Arodasi, New York.

THE ENGINEERING MAGAZINE.
120-122 Liberty St., New York, U. S. A.

AUTHORS AND PAPERS FOR SEPTEMBER.

VICE ADMIRAL P. H. COLOMB, R. N. (*The Essential Elements of Modern Sea Power*)=Born in Scotland, 1831; entered the Royal Navy 1846; served on the coast of Portugal, suppressing the slave trade, 1847; in China suppressing piracy, 1849-51; Burmese war, 1852; Arctic Exploration, 1854; commanded the Dryad, in suppression of the slave trade, 1868-1870; commanded the Audacious in China 1874-77 and the Thunderer, in the Mediterranean, 1880-81; captain of the steam reserve, Portsmouth, 1884-86; flag captain, Portsmouth, 1884-86; compulsorily retired for age, 1886. Introduced a system of signals in the army, 1859, and invented the flashing signals for the navy, now adopted universally, in 1867; devised the system of steam tactics, ever since used, in 1865; invented the system of interior lighting for warships, 1873; constantly working for amendment of rules, etc., for preventing collisions at sea, until final success at the Washington maritime conference, 1889; president of many departmental committees, and author of many important books, essays, reports and other publications.

HIRAM STEVENS MAXIM (*Engineering Lessons from the Hispano-American War*) =Mr. Maxim was born in 1840, in the State of Maine, and began his mechanical career in a machine works in Fitchburg, Mass., U. S. A., as a lathe-hand, and in other manual capacities. In 1881, his self-regulating current machine at the Paris Exposition brought him the decoration of *Chevalier de la Légion d'Honneur*. In 1881 82, Mr. Maxim made working drawings of his automatic gun, and in 1883 the first example of this now celebrated weapon was constructed under his superintendence in Hatton Garden. At this period he patented his electrical training-gear for large guns. He is widely known also through his experiments in aeronautics.

GUSTAV LINDENTHAL (*European and American Bridge Construction*)=Chief Engineer of the North River Bridge Company, authorized by the Congress of the United States to construct a bridge across the Hudson river at 23d Street in New York across to Hoboken; is a member of the American Society of Civil Engineers, of the Canadian Society of Civil Engineers, and of the Institution of Civil Engineers; also a fellow of the American Association for the Advancement of Science, and of other scientific organizations. His professional work covers many branches of civil engineering, especially in the department of bridge design.

WILLIAM O. WEBBER (*The Comparative Cost of Steam and Water Power*)=Born Springfield, Mass., 1856; educated in public schools of Manchester and Portsmouth, N. H., and in New York city. Mechanical engineer 1875, Toledo, Peoria & Warsaw Ry., Peoria Ill.; engineering representative, 1876, Centennial Exhibition, Chapman Valve Co., and assistant in turbine tests; engineer of tests, 1876-81, Chicago, Burlington & Quincy R. R., Aurora, Ill.; superintendent, 1881-82, Allen Paper Car Wheel Works, Pullman, Ill.; superintendent and partner, 1882-87, Lawrence Machine Co., Lawrence, Mass.; general superintendent, 1889-94, Erie City Iron Works, Erie, Pa.; at present consulting engineer in Boston, Mass.; is a member of the American Society of Mechanical Engineers, and Boston Society of Civil Engineers, and an associate member of the United States Naval Institute.

J. SINCLAIR FAIRFAX (*Some Comparative Points of International Patent Law*)=Born in Yorkshire, November, 1842, privately educated, and studied engineering, &c., in London. Went to the United States at the end of 1863, engaged with R. Hoe & Co., and the Baltimore and Ohio Railroad; practised in Wheeling, West Virginia, for upwards of 12 years, being appointed architect of the State Penitentiary, and State Capitol of West Virginia. His plans

for the Centennial International Exhibition of 1876, at Philadelphia, were premiated; and he also designed and made the working drawings of blast furnaces, gas works, iron works, and railroad workshops. He returned to England in 1877, and has practised since as a patent agent and consulting engineer. He is now serving a second term as President of the Society of Patent Agents, and is an Associate of the Institutions of Naval Architects, and Electrical Engineers.

FREDERICK E. COOPER (*The Underground Railways of London*)=After three years pupilage with a civil engineer, joined the staff of Sir John Fowler, the engineer of the original underground railway, in 1863, and from 1866 to 1871 was his resident engineer during the construction of the Metropolitan & District Railway; afterwards, from 1886 to 1890 acted in a similar capacity for that gentleman and his partner, Sir Benjamin Baker, during the construction of the Forth Bridge and connecting railways; is a member of the Institution of Civil Engineers.

RUDOLPH HERING (*Bacterial Processes of Sewage Disposal*)=Born Philadelphia, Pa.; educated in Dresden, Germany, 1860 to 1867, graduating from the Saxon Polytechnic College as Civil Engineer; commenced practice as rodman in Prospect Park, Brooklyn; subsequently assistant engineer in charge of construction of Fairmount Park, Philadelphia; joined the U. S. Geological Survey in 1872; assistant engineer in engineering department of the city of Philadelphia, in charge of bridges and sewers, leaving this position in 1880, under commission by the United States National Board of Health to investigate the character and success of the European sewerage works; results of this investigation published in annual report of the board for 1881; in 1883-1886 made extensive surveys and investigations for future water supply of Philadelphia; chief engineer of Water-Supply and Drainage Commission 1886; Commissioner of Public Works, and made report on sewerage improvements for New York City, in 1887; chairman of Board of Engineers appointed by President Harrison in 1889, for city of Washington; designed sewerage and water-supply systems for Santos, Brazil, for Honolulu, Hawaii, and many other cities; a consulting engineer and designer of wide fame, and an author of many authoritative essays; member of the Institution of Civil Engineers, the American Society of Civil Engineers, the Canadian Society of Civil Engineers, the Verein Deutscher Ingenieure and many other societies.

CHARLES HENRY DAVIS, C. E. (*The Application of Alternating Currents to Electric Traction*)=Born 1865, Montgomery County, Pa. Educated in Europe and in U. S. Entered Towne Scientific School, University of Pennsylvania, 1881, entered School of Mines, Columbia College, 1883, graduating 1887 with degree of C. E. 1887-89 with Thomson Houston, Sawyer-Man and Westinghouse Electric Companies in factory, construction work and as agent. 1889 to date, professional engineering, with offices in New York, Boston and Philadelphia.

HOWARD C. FORBES (*The Application of Alternating Currents to Electric Traction*)=Born 1868, Cambridge, Mass.; educated at Massachusetts Institute of Technology, entering 1887, taking degree of Chemical Engineering in 1891, and Electrical Engineering 1892; 1892 to date in professional engineering.

DAVID A. LOUIS (*The Baku Petroleum District of Russia*)=Born in London; studied at the Royal School of Mines; worked as chemist, metallurgist and mining engineer in different industries and educational undertakings in Europe and the United States, incidentally lecturing as well as reporting and contributing to technical literature, being more particularly identified in the latter direction with:—O'Driscoll's "Notes on the Treatment of Gold Ores"; the article "Miners' Safety Lamps" in Groves & Thorp's Chemical Technology; communications relating to ore-dressing, basic slag, the cyanide process, coke ovens, the iron industry of Hungary, etc., and with the Mining and Metallurgical Department of this Magazine. Has also acted as Assistant Examiner in mining for the Government Department of Science and Arts in London; consulting Mining Engineer, Fellow of the Institute of Chemistry and of the Chemical Society; member of the American Institute of Mining Engineers, of the N. of England Institute of Mining and Mechanical Engineers and the Federated Institute of Mining Engineers, of the Mining Association and Institute of Cornwall, of the Society of Chemical Industry and the Berlin Chemical Society.

HENRY ROLAND (*Effective Systems for Finding and Keeping Shop-Costs*)=A writer of wide practical, personal experience in every department of the shop, from the position of journeyman to that of manager in some of the principal establishments in the United States. He has had remarkable facilities for studying the methods of the most advanced and successful shops, and has derived unusual profit from the study on account of his personal familiarity with the practical aspects of the work.

Guaranteed to be equal to any imported cement.

Atlas Portland Cement.

A few of the many Engineers who are large users of Atlas Portland Cement.

Chas. Sooysmith, New York.
Alfred P. Boller, New York.
Thos. C. Clark, New York.
George S. Greene, Eng.-in-Chief of New York Department of Docks.
Walter Katte, Chief Engineer N. Y. C. & H. R. R. R.
Maj. W. H. Marshall, U. S. Engineer, Chicago, Ill.
William B. Parsons, New York.
T. T. Johnston, Assistant Chief Engineer Sanitary District, Chicago, Ill.
Geo. H. Benzenberg, City Engineer and President Board of Public Works, Milwaukee, Wis.
John F. Stevens, Chief Engineer Great Northern R. R.
Wilkins & Davison, Civil Engineers, Pittsburg, Pa.
B. J. T. Jnep, City Engineer, Indianapolis, Ind.
M. L. Holman, Water Commissioner, St. Louis, Mo.
A. L. Milner, Street Commissioner, St. Louis, Mo.
A. H. French, Brookline, Mass.
William Jackson, Boston, Mass.
Earnest Adam, City Engineer, Newark, N. J.

ATLAS CEMENT CO., 143 Liberty Street, New York.

IMPROVED TRANSITS AND LEVELS . . . .

220 p. Illustrated Catalogue mailed free ONLY if this ad. is mentioned.

Graduated entirely on our large divided engines. Special award at World's Fair. All kinds of Engineering, Surveying and Drafting instruments and materials.

QUEEN & CO., Inc.

N. Y. OFFICE, 116 FULTON ST. **PHILADELPHIA.**

Dixon's Pure Flake Graphite

Is a Blessing to Every Engine Room and Machine Shop.

A small quantity added to any Oil or Grease largely increases its lubricating value and makes the finest Cooling Mixture.

Pamphlet and Sample Sent Free.

JOS. DIXON CRUCIBLE CO., Jersey City, N. J.

SUGAR MACHINERY,

HENRY G. MORRIS.

926 DREXEL BLDG.,
PHILADELPHIA, PA., U. S. A.

WESTON CENTRIFUGALS, VACUUM PANS.

SPECIAL DESIGNS AND ESTIMATES.

PUNCHES AND SHEARS,
PLATE PLANERS,
STRAIGHTENING ROLLS,
BENDING ROLLS,
AND A NUMBER OF

Special Machines

...FOR...

RIVETED PIPE PLANTS,
BRIDGE WORKS,
BOILER AND TANK SHOPS,
SHIP YARDS, ETC.

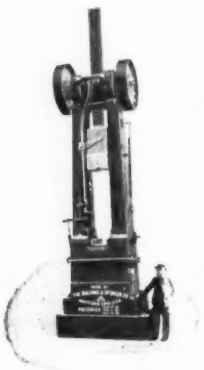
HILLES & JONES COMPANY,
904 Church St., Wilmington, Delaware.

Walworth High Pressure Valves, Fittings & Bent Pipe.

Brass and Iron Goods and Tools.

WALWORTH MFG. CO.,
14 to 24 Oliver St., **BOSTON.**

Please mention The Engineering Magazine when you write.



Complete

DROP FORGING PLANTS,

DROP FORGINGS AND MACHINISTS' TOOLS.

Send for Catalogue.

THE BILLINGS & SPENCER CO.,

HARTFORD, CONN., U. S. A.

U. S. INJECTOR

THE PEER OF ALL AUTOMATIC INJECTORS AND GUARANTEED SUPERIOR.

Saves Coal, Steam and Labor.

ECONOMICAL AND SAFE.

Catalogue Free if Engineering Magazine is mentioned.

AM. INJECTOR CO.,
DETROIT, MICH.

MALLEABLE NICKEL, SHOT, PLATES, INGOTS, BARS, SHEETS, WIRE.

Best quality for Anodes, German-Silver and Nickel-Steel.

ORFORD COPPER CO.,
37 Wall Street,
New York.

THE CANADIAN COPPER CO.,
12 Wade Building,
Cleveland, Ohio.

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO. HARTFORD, CONN.

THOROUGH INSPECTIONS

...AND..

Insurance against Loss or Damage to Property and Loss of Life and Injury to Persons caused by

Steam Boiler Explosions.

J. M. ALLEN, PRESIDENT.
WM. B FRANKLIN, VICE-PRESIDENT.
F. B. ALLEN, SECOND VICE-PRESIDENT.
J. B. PIERCE SECRETARY AND TREASURER.
L. B. BRAINERD, ASSISTANT TREASURER.
L. F. MIDDLEBROOK, ASST. SECRETARY.

LATEST PUBLICATIONS.

The Coffer-Dam Process for Piers.
Practical Examples from Actual Work—By CHARLES E. FOWLER. 8vo, cloth..... ...$2.50

Inspection of Materials and Workmanship Employed in Construction—
By AUSTIN T. BYRNE. 12mo, cloth... 3.00

Text-Book of Geodetic Astronomy—
By JOHN F. HAYFORD. 8vo, cloth... 3.00

Prismoidal Formulæ and Earthworks—
By THOS. U. TAYLOR. 8vo, cloth.... 1.50

De Pontibus—
A Pocket-Book for Bridge Engineers. 12mo, morocco..... 3.00

A Treatise on the Military Law of the United States—
By Lt.-Col. G.B. DAVIS, Deputy Judge-Advocate General, U.S.A. 8vo, cloth $7 00, sheep..... 7.50

JOHN WILEY & SONS,
53 East 10th Street,
NEW YORK CITY.

Plea e mention The Engineering Magazine when you write.

A Buyers' Directory of

THE ENGINEERING TRADES.

NOTE.—*The display advertisements of the firms mentioned under each heading can be found readily by reference to the Alphabetical Index on page 23.*

Acid Works Castings.
Phosphor-Bronze Smelting Co., Ltd., Phila., Pa.

Advertising Experts.
Manufacturers' Advertising Bureau, 126 Liberty St., New York.

Air Brakes.
New York Air Brake Co., 66 Broadway, New York.
Westinghouse Air Brake Co., Pittsburg, Pa.

Air and Gas Compressors.
Edw. P. Allis Co., Milwaukee, Wis.
American Well Works, Aurora, Ill.
E. W. Bliss Co., Brooklyn, N. Y.
Clayton Air-Compressor Wks., 26 Cortlandt St., N.Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Guild & Garrison, Brooklyn, N. Y.
Hall Steam Pump Co., Pittsburg, Pa.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Laidlaw-Dunn-Gordon Co., Cincinnati, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, N. Y.
Sullivan Machinery Co., Chicago, Ill.

Anti-Friction Metals.
North American Metaline Co., 141-149 Third St., Long Island City, N. Y.
Phosphor Bronze Smelting Co., Ltd., Phila., Pa.

Architectural Iron.
Chester B. Albree, Allegheny, Pa.
Continental Iron Works, Brooklyn, N. Y.
Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.
Winslow Bros. Co., Chicago, Ill.

Architectural Sheet Metal Works.
Cincinnati Corrugating Co., Piqua, Ohio.

Artesian Wells.
Cole Brothers, 102 Fulton St., New York.

Ballast Unloaders.
Marion Steam Shovel Co., Marion, Ohio.

Batteries, Electric.
Electric Storage Battery Co., Philadelphia, Pa.

Belt Cement.
Shultz Belting Co., St. Louis, Mo.

Belting Conveyors.
Robins Conveying Belt Co., 147 Cedar St., New York.

Belt Dressing.
Jos. Dixon Crucible Co., Jersey City, N. J.

Belting.
Boston Belting Co., Boston, Mass.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.
Main Belting Co., Philadelphia, Pa.
New York Belting & Packing Co., Ltd., New York.
Robins Conveying Belt Co., 147 Cedar St., New York.

Belt Lacing.
Bristol Co., Waterbury, Conn.

Bending Rolls.
Hilles & Jones Co., Wilmington, Del.
Long & Allstatter Co., Hamilton, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Bicycle Forgings.
J. H. Williams & Co., Brooklyn, N. Y.

Bicycle Frame Drilling Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Blacksmiths' Tools.
Buffalo Forge Co., Buffalo, N. Y.
Hammacher, Schlemmer & Co., 209 Bowery, N. Y.
Montgomery Company, 105 Fulton St., N. Y.

Blast Furnaces, Gas.
American Gas Furnace Co., Elizabeth, N. J.

Blowers.
American Blower Co., Detroit, Mich.
American Gas Furnace Co., 23 John St., New York.
Buffalo Forge Co., Buffalo, N. Y.
Gates Iron Works, Chicago, Ill.
B. F. Sturtevant Co., Boston, Mass.

Boilers.
Almy Water-Tube Boiler Co., Providence, R. I.
American Well Works, Aurora, Ill.
Atlantic Works, East Boston, Mass.
Edw. P. Allis Co., Milwaukee, Wis.
Chandler & Taylor Co., Indianapolis, Ind.
Clonbrock Steam Boiler Co., Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gas Engine & Power Co., Morris Heights, New York City.
Gates Iron Works, Chicago, Ill.
Hazelton Boiler Co., 716 E. 13th St., New York.
Pittsburg Locomotive Works, Pittsburg, Pa.
Charles L. Seabury & Co., Morris Heights, New York City.
Star Drilling Machine Co., Akron, Ohio.
Stearns Manufacturing Co., Erie, Pa.
Taunton Locomotive Mfg. Co., Taunton, Mass.
Thorpe, Platt & Co., New York.
Robt. Wetherill & Co., Chester, Pa.

For Alphabetical Index to Advertisers, see page 23.

Boiler Fronts and Fittings.
Vulcan Iron Works, Toledo, Ohio.
Walworth Manufacturing Co., Boston, Mass.

Boiler Compounds.
Dearborn Drug & Chemical Works, 29 Rialto Chicago, Ill.

Boiler Inspectors.
Hartford S. B. I. & Ins. Co., Hartford, Conn.

Boiler-Makers' Tools.
Hammacher, Schlemmer & Co., 209 Bowery, N. Y.
Hilles & Jones Co., Wilmington, Del.
Stow Flexible Shaft Co., Philadelphia, Pa.

Bolt Cutters.
Acme Machinery Co , Cleveland, Ohio.
Montgomery Company, 105 Fulton St., N. Y.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Bolt and Rivet Headers.
Acme Machinery Co., Cleveland, Ohio.

Books.
Wm. T. Comstock, 23 Warren St , New York.
Engineering Magazine, 120-122 Liberty St., New York.
John Wiley & Sons, 53 East Tenth St., New York.

Boring Machines.
E. W. Bliss Co., Brooklyn, N. Y.
Montgomery Company, 105 Fulton St., New York.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Box Makers' Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.

Bricks.
Henry Maurer & Son, 420 E. 23d St., New York.

Brick and Tile Machinery.
F. D. Cummer & Son Co., Cleveland, Ohio.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.

Bridge Builders.
Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.

Bridge Railing.
Chester B. Albree, Allegheny, Pa.

Builders' Elevators.
American Hoist & Derrick Co., St. Paul, Minn.
John F. Byers Machine Co., Ravenna, Ohio.
Lidgerwood Mfg. Co., 96 Liberty St., New York.

Building Materials.
Chester B. Albree, Allegheny, Pa.
Berlin Iron Bridge Co., East Berlin, Conn.
T. H. Brooks & Co., Cleveland, Ohio.
Cincinnati Corrugating Co., Piqua, Ohio.
Detroit Graphite Mfg. Co., Detroit, Mich.
Joseph Dixon Crucible Co., Jersey City, N. J.
H. W. Johns Mfg. Co , 100 William St., New York.
Henry Maurer & Son, 420 E. 23d St., New York.
Passaic Rolling Mill Co., Paterson, N. J.
Pittsburgh Terra Cotta Lumber Co., Pittsburg, Pa.
Winslow Bros. Co., Chicago, Ill.

Cable-Railway Driving-Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
Robt. Wetherill & Co., Chester, Pa.

Cables, Electric and Submarine.
Okonite Co., Ltd., 253 Broadway New York.

Cableways.
Fraser & Chalmers, Chicago, Ill.
Lidgerwood Mfg. Co., 96 Liberty St., New York.

Cables, Wire.
American Hoist & Derrick Co., St. Paul, Minn.
Cooper, Hewitt & Co , 17 Burling Slip, New York.
John A. Roebling's Sons Co., Trenton, N. J.
Trenton Iron Co., Trenton, N. J.

Calcining and Drying Machines.
F. D. Cummer & Son Co., Cleveland, Ohio.

Calculating Machines.
Felt & Tarrant Mfg. Co., Chicago, Ill.

Cams and Tappets.
Chrome Steel Works Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.

Card Index Files.
Globe Company, Cincinnati, Ohio.

Car Shop Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.

Carriage and Wagon Machinery.
Buffalo Forge Co., Buffalo, N. Y.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Castings, Iron and Steel.
Edw. P. Allis Co., Milwaukee, Wis.
Berlin Iron Bridge Co., East Berlin, Conn.
Buffalo Forge Co., Buffalo, N. Y.
Chrome Steel Works, Brooklyn, N. Y.
Stanley G. Flagg & Co., Philadelphia, Pa.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
McNeal Pipe & Foundry Co., Burlington, N. J.
Ohio Pipe Co., Columbus, Ohio.
Taunton Locomotive Mfg. Co., Taunton, Mass.
Walworth Manufacturing Co , Boston, Mass.
R. D. Wood & Co. Philadelphia, Pa.

Cement.
Atlas Cement Co., 143 Liberty St., New York.

Centrifugal Pumps.
Bucyrus Co., So. Milwaukee, Wis.

Centrifugals.
Henry G. Morris, Philadelphia, Pa.

Cesspool Cleaning Apparatus.
Odorless Excavating Co., Boston, Mass.

Chain Belting.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.

Chain Pipe Wrenches.
J. H. Williams & Co., Brooklyn, N. Y.

Chemical Works Machinery.
Atlantic Works, East Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Chemists' Manufacturing.
Roessler & Hasslacher Chemical Co., New York.

Chemists—Water and Oil.
Dearborn Drug & Chemical Works, 29 Rialto, Chicago, Ill.

For Alphabetical Index to Advertisers, see page 23.

Chloride of Lime.
Roessler & Hasslacher Chem. Co., 100 William St., New York.

Clay-Working Machinery.
W. J. Clark & Co., Salem, Ohio.
F. D. Cummer & Son Co., Cleveland, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Coal- and Ashes-Handling Machinery.
C. W. Hunt Co., 45 Broadway, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.

Coal-Mining Machinery.
Buffalo Forge Co., Buffalo, N. Y.
W. J. Clark & Co., Salem, Ohio.
Lambert Hoisting Engine Co., Newark, N. J.
Arthur Koppel, 68 Broad St., New York.
John H. McGowan Co., Cincinnati, Ohio.
C. W. Hunt Co., 45 Broadway, New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, New York.
Sullivan Machinery Co., Chicago, Ill.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Coal-Washing Machinery.
Jeffrey Mfg Co., Columbus, Ohio.

Cold Saws.
Q & C Company, Chicago, Ill.

Compressed Air Hoists and Motors.
Stow Flexible Shaft Co., Philadelphia, Pa.

Compressed-Air Shop Tools.
Clayton Air Compressor Works, 26 Cortlandt St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.

Concentrators and Pulverizers.
Bradley Pulverizer Co., Boston, Mass.
F. D. Cummer & Son Co., Cleveland, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Stedman's Foundry & Mch. Co., Aurora, Ind.

Condensers.
Edw. P. Allis Co., Milwaukee, Wis.
Deane Steam Pump Co., Holyoke, Mass.
Wm. Baragwanath & Son, Chicago, Ills.
Fraser & Chalmers, Chicago, Ill.
Laidlaw-Dunn-Gordon Co., Cincinnati, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Consulting Engineers.
Alton D. Adams, Worcester, Mass.
Blood & Hale, Boston, Mass.
A. B. Bowers, San Francisco, Cal.
Century Engineering Co., Cleveland, Ohio.
W. C. Dodge, 700 Ninth St., Washington, D. C.
W. Dusedau, Brooklyn, N. Y.
Julian Kennedy, Pittsburg, Pa.
Alexander Potter, New York and Pittsburg.
C. L. Redfield, Chicago, Ill.
Sydney F. Reynolds, Torry, Pa.
H. B. Roelker, 41 Maiden Lane, New York.
Wm. O. Webber, Boston, Mass.

Contractors.
A. B. Bowers, San Francisco, Cal.
Century Engineering Co., Cleveland, Ohio.
Julian Kennedy, Pittsburg, Pa.

Contractors' Dump Cars, etc.
Gates Iron Works, Chicago, Ill.
Arthur Koppel, 68 Broad St., New York.

Contractors' Supplies.
American Hoist & Derrick Co., St. Paul, Minn.
John F. Byers Machine Co., Ravenna, Ohio.
Chicago Flexible Shaft Co., Chicago, Ill.
Contractors' Plant Mfg. Co., Buffalo, N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.
Robins Conveying Belt Co., 147 Cedar St., New York.
Stearns Mfg. Co., Erie, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Vulcan Iron Works, Toledo, Ohio.
Watson & Stillman Co., 210 E. 43d St., New York.

Conveying Machinery.
W. J. Clark & Co., Salem, Ohio.
Frick Company, Waynesboro, Pa.
C. W. Hunt Co., 45 Broadway, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Link-Belt Engineering Co., Philadelphia, Pa.
Robins Conveying Belt Co., 147 Cedar St., New York.
John A. Roebling's Sons Co., Trenton, N. J.

Copper.
Canadian Copper Co., Cleveland, O.
Orford Copper Co., 37 Wall St., New York.

Corrugated Copper Tubes.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Corrugated Iron.
Berlin Iron Bridge Co., East Berlin, Conn.
Cincinnati Corrugating Co., Piqua, Ohio.

Cranes.
American Hoist & Derrick Co., St. Paul, Minn.
Berlin Iron Bridge Co., East Berlin, Conn.
Brown Hoisting & Conveying Machine Co., Cleveland, Ohio.
Wm. Sellers & Co., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Crusher Plates.
Chrome Steel Works, Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Crushers—Ore, Phosphate, Rock.
Edw. P. Allis Co., Milwaukee, Wis.
American Hoist & Derrick Co., St. Paul, Minn.
Bradley Pulverizer Co., Boston, Mass.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg Co., Columbus, Ohio.
Chrome Steel Works, Brooklyn, N. Y.
Stedman's Foundry & Mch. Co., Aurora, Ind.

Cyanide.
Roessler & Hasslacher Chemical Co., New York.

Cylinder Boring and Facing Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Diamond Drills.
American Well Works, Aurora, Ill.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Sullivan Machinery Co., Chicago, Ill.
Rand Drill Co., 100 Broadway, New York.

For Alphabetical Index to Advertisers, see page 23.

Dies and Die Forgings.
E. W. Bliss Co., Brooklyn, N. Y.
Ferracute Machine Co., Bridgeton, N. J.
Montgomery Company, 105 Fulton St., New York.
Walworth Manufacturing Co., Boston, Mass.

Die and Drill Steel.
Chrome Steel Works, Brooklyn, N. Y.
Hobson, Seaman & Co., 97 John St., New York.
Wm. Jessop & Sons, Ltd., 91 John St., New York.

Digesters.
Atlantic Works, East Boston, Mass.

Drawing Instruments and Materials.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Montgomery Company, 105 Fulton St., New York.
Queen & Co., Inc., Philadelphia, Pa.

Dredging Machines.
A. B. Bowers, San Francisco, Cal.
Bucyrus Co., So. Milwaukee, Wis.
W. J. Clarke & Co, Salem, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
New York Dredging Co., 61 Park Row, New York.
Vulcan Iron Works, Toledo, Ohio.

Drills—Rock and Coal.
American Hoist & Derrick Co., St. Paul, Minn.
M. C. Bullock Mfg. Co., Chicago, Ill.
Ingersoll-Sergeant Drill Co., 25 Cortlandt St., N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Rand Drill Co., 100 Broadway, New York.
Star Drilling Machine Co , Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Drilling Machines.
W. F. & John Barnes Co., Rockford, Ill.
Bement, Miles & Co., Philadelphia, Pa.
Buffalo Forge Co., Buffalo, N. Y.
Chicago Flexible Shaft Co., Chicago, Ill.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Hamilton Machine Tool Co., Hamilton, Ohio.
Hilles & Jones Co , Wilmington, Del.
Montgomery Company, 105 Fulton Street, New York.
Niles Tool Works, Hamilton, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Drop Forging Plants.
Billings & Spencer Co., Hartford, Conn.

Drop Hammers.
Billings & Spencer Co., Hartford, Conn.
E. W. Bliss Co., Brooklyn, N. Y.
Long & Allstatter Co., Hamilton, Ohio.

Drying and Calcining Machines.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
F. D. Cummer & Son Co., Cleveland, Ohio.
Gates Iron Works, Chicago, Ill.
Harrison Safety Boiler Works, Philadelphia, Pa.
Jeffrey Mfg. Co., Columbus, Ohio.
B. F. Sturtevant Co., Boston, Mass.

Dynamos.
American Engine Co., Bound Brook, N. J.
H. B. Coho & Co., 203 Broadway, New York.
Ft. Wayne Electric Corporation, Ft. Wayne, Ind.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Keystone Electric Co., Erie, Pa.
B. F. Sturtevant Co., Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg Co., Pittsburg, Pa.

Electrical Machinery and Supplies.
American Engine Co., Bound Brook, N. J.
Bristol Co., Waterbury, Conn.
H. B. Coho & Co., New York.
Electric Storage Battery Co., Philadelphia, Pa.
Ft. Wayne Electric Corporation, Ft. Wayne, Ind.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Keystone Electric Co , Erie, Pa.
Queen & Co., Inc., Philadelphia, Pa.
Wm. E. Quimby, 86 Liberty St., New York.
B. F. Sturtevant Co., Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Weston Electrical Instrument Co., Newark, N. J.

Electric Locomotives.
Baldwin Locomotive Works, Philadelphia, Pa.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
H. K. Porter & Co., Pittsburg, Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Elevator Buckets.
W. J. Clark & Co., Salem, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.

Elevator Guards and Screens.
Harrington & King Perforating Co., Chicago, Ill.

Elevators.
Gates Iron Works, Chicago, Ill.
Morse, Williams & Co., Philadelphia, Pa.
Triumph Electric Co., Cincinnati, Ohio.
R. D. Wood & Co., Philadelphia, Pa.

Emery Wheels.
Carborundum Co., Niagara Falls, N. Y.
Montgomery Company, 105 Fulton St., New York.
New York Belting & Packing Co., Ltd., New York.

Emery-Wheel Machinery.
Chicago Flexible Shaft Co., Chicago, Ill.
Stow Flexible Shaft Co., Philadelphia, Pa.

Engineers.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Engineers' Wrenches.
J. H. Williams & Co., Brooklyn, N. Y.

Engineering Instruments.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Queen & Co., Inc., Philadelphia, Pa.

Engines, Blowing.
Edw. P. Allis Co., Milwaukee, Wis.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Fraser & Chalmers, Chicago, Ill.
B. F. Sturtevant Co., Boston, Mass.

Engines—Gas, Gasoline, and Petroleum.
American Well Works, Aurora, Ill.

For Alphabetical Index to Advertisers, see page 23.

Daimler Motor Works, Steinway, Long Island City, N. Y.
Otto Gas Engine Works, Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Engines, Marine.
Atlantic Works, East Boston, Mass.
Gas Engine & Power Co, Morris Heights, New York City.
Marine Iron Works, Station A, Chicago, Ill.
Charles L. Seabury & Co., Morris Heights, New York City.

Engines, Stationary.
Edw. P. Allis Co., Milwaukee, Wis.
American Blower Co., Detroit, Mich.
American Engine Co., Bound Brook, N. J.
American Well Works, Aurora, Ill.
John F. Byers Machine Co., Ravenna, Ohio.
Buffalo Forge Co., Buffalo, N. Y.
Bullock Mfg. Co., M C., Chicago, Ills.
Chandler & Taylor Co., Indianapolis, Ind.
Frick Company, Waynesboro, Pa.
Gates Iron Works, Chicago, Ill.
Hooven, Owens & Rentschler Co., Hamilton, Ohio.
Star Drilling Machine Co., Akron, Ohio.
Stearns Manufacturing Co., Erie, Pa.
B. F. Sturtevant Co., Boston, Mass.
Vilter Manufacturing Co., Milwaukee, Wis.
Webster, Camp & Lane Machine Co., Akron, Ohio.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Robert Wetherill & Co., Chester, Pa.

Excavators.
A. B. Bowers, San Francisco, Cal.
Bucyrus Co., So. Milwaukee, Wis.
Jeffrey Mfg. Co., Columbus, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
New York Dredging Co., 61 Park Row, New York.
Vulcan Iron Works, Toledo, Ohio.

Exhaust Heads.
A. A. Griffing Iron Co., 66-68 Center St., New York.

Fans, Ventilating.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Fraser & Chalmers, Chicago, Ill.
B. F. Sturtevant Co., Boston, Mass.

Feed-Water Heaters.
Edw. P. Allis Co., Milwaukee, Wis.
Broomell, Schmidt & Co., York, Pa.
Fraser & Chalmers, Chicago, Ill.
Fuel Economizer Co., Matteawan, N. Y.
A. A. Griffing Iron Co., 66-68 Center St., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Manufacturing Co., Springfield, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
National Pipe Bending Co., New Haven, Conn.
Taunton Locomotive Mfg. Co., Taunton, Mass.
Robt. Wetherill & Co., Chester, Pa.

Feed-Water Purifiers.
Fraser & Chalmers, Chicago, Ill.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Manufacturing Co., Springfield, Ohio.

Ferro-Silicon.
Carborundum Co., Niagara Falls, N. Y.

Fertilizer Machinery.
Bradley Pulverizer Co., Boston, Mass.
Jeffrey Mfg. Co., Columbus, Ohio.
Stedman's Foundry & Mch. Works, Aurora, Ind.

Files.
Nicholson File Co., Providence, R. I.

Filters.
New York Filter Mfg. Co., New York.

Fire Hydrants.
R. D. Wood & Co., Philadelphia, Pa.

Flexible Shafts.
Chicago Flexible Shaft Co., Chicago, Ill.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Floor and Sidewalk Lights.
T. H. Brooks & Co., Cleveland, Ohio.

Flour-Mill Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
W. J. Clark & Co., Salem, Ohio.

Fly Wheels.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.

Forges.
Buffalo Forge Co., Buffalo, N. Y.
Montgomery Company, 105 Fulton St., New York.
B. F. Sturtevant Co., Boston, Mass.

Forgings, Iron and Steel.
Chester B. Albree, Allegheny, Pa.
Billings & Spencer Co., Hartford, Conn.
Keystone Drop Forge Co., Philadelphia, Pa.
Strieby & Foote, Newark, N. J.
J. H. Williams & Co., Brooklyn, N. Y.

Forming Machines.
Hilles & Jones Co., Wilmington, Del.
Long & Allstatter Co., Hamilton, Ohio.

Foundation Soundings.
Cole Brothers, 102 Fulton St., New York.

Friction Clutches.
Eastern Machinery Co., New Haven, Conn.
Reeves Pulley Co., Columbus, Indiana.

Furnace Builders.
Julian Kennedy, Pittsburg, Pa.

Furniture.
Globe Company, Cincinnati, Ohio.
Heber Wells, New York.

Furniture and Chair Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.

Gages—Pressure, Steam, Water, etc.
Bristol Co., Waterbury, Conn.
Montgomery Company, 105 Fulton St., New York.
Walworth Manufacturing Co., Boston, Mass.

Gas Fixtures.
Walworth Manufacturing Co., Boston, Mass.

Gas Holders.
R. D. Wood & Co., Philadelphia, Pa.
United Gas Improvement Co., Philadelphia, Pa.

Gaskets.
Peerless Rubber Mfg. Co., 16 Warren St., New York.

Gas Machines and Generators.
American Gas Furnace Co., 23 John St., New York.
United Gas Improvement Co., Philadelphia, Pa.
Walworth Manufacturing Co., Boston, Mass.

For Alphabetical Index to Advertisers, see page 23.

Gas Plants.
American Gas Furnace Co., 23 John St., New York.
United Gas Improvement Co., Philadelphia, Pa.

Gas Producers.
R. D. Wood & Co., Philadelphia, Pa.
United Gas Improvement Co., Philadelphia, Pa.

Gas-Works Machinery.
R. D. Wood & Co., Philadelphia, Pa.
United Gas Improvement Co., Philadelphia, Pa.

Gate Valves.
Jenkins Brothers, 71 John Street, New York.
Lunkenheimer Co., Cincinnati, Ohio.
Walworth Manufacturing Co., Boston, Mass.

Gear Cutters,
E. W. Bliss Co., Brooklyn, N. Y.
Hugo Bilgram, 440 No. 12th St., Philadelphia, Pa.
Montgomery Company, 105 Fulton St., New York.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Gearing.
Edw. P. Allis Co., Milwaukee, Wis.
Gleason Tool Co., 4 Race St., Rochester, N. Y.
Hugo Bilgram, 440 No. 12th St., Philadelphia, Pa.
Jeffrey Mfg. Co., Columbus, Ohio.
Montgomery Company, 105 Fulton St., New York.
Morse, Williams & Co., Philadelphia, Pa.
New Process Rawhide Co., Syracuse, N. Y.
Stow Flexible Shaft Co., Philadelphia, Pa.

Girders.
Chester B. Albree, Allegheny, Pa.
Berlin Iron Bridge Co., East Berlin, Conn.

Glass Polishing Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Golf Club Heads.
J. H. Williams & Co., Brooklyn, N. Y.

Grain Elevator Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
W. J. Clark & Co., Salem, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.

Grates.
Vulcan Iron Works, Toledo, Ohio.

Grinding and Polishing Machinery.
Chicago Flexible Shaft Co., Chicago, Ill.
Cleveland Twist Drill Co., Cleveland, Ohio.
Landis Tool Co., Waynesboro, Pa.
Montgomery Company, 105 Fulton St., New York.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.

Grips, Cable Railways.
Robt. Wetherill & Co., Chester, Pa.

Hangers—See Pulleys.

Heating and Ventilating Apparatus.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
B. F. Sturtevant Co., Boston, Mass.

Heaters, Steam and Hot Water.
Gorton & Lidgerwood Co., 96 Liberty St., N. Y.
H. B. Smith Co., 137 Center St., New York.
Walworth Manufacturing Co., Boston, Mass.

Helve Hammers.
Long & Allstatter Co., Hamilton, Ohio.

Hoisting Engines and Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
American Hoist & Derrick Co., St. Paul, Minn.
Brown Hoisting & Conveying Machine Co., Cleveland, Ohio.
John F. Byers Machine Co., Ravenna, Ohio.
Contractors' Plant Mfg. Co., Buffalo, N. Y.
Cooper, Hewitt & Co., 17 Burling Slip, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
C. W. Hunt Co., 45 Broadway, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Lambert Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stearns Manufacturing Co., Erie, Pa.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.
Webster, Camp & Lane Machine Co., Akron, Ohio.

Hollow Bricks.
Henry Maurer & Son, 420 East 23d St., New York.
Pittsburgh Terra Cotta Lumber Co., Pittsburg, Pa.

Hydrants.
R. D. Wood & Co., Philadelphia, Pa.

Hydraulic Cement.
Atlas Cement Co., 143 Liberty St., New York.

Hydraulic Engine.
Rife Engine Co., 126 Liberty St., New York.

Hydraulic Machinery.
John H. McGowan Co., Cincinnati, Ohio.
Rife Engine Co., 126 Liberty St., New York.
Watson & Stillman Co., 210 E. 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

Ice Plants.
Westinghouse Machine Co., Pittsburg, Pa.

Ice-Making Machinery.
Frick Company, Waynesboro, Pa.
H. B. Roelker, 41 Maiden Lane, New York.
Stillwell Bierce & Smith-Vaile Co., Dayton, Ohio.
Vilter Manufacturing Co., Milwaukee, Wis.

Ice and Refrigeration.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Indicators, Steam-Engine.
Queen & Co., Inc., Philadelphia, Pa.

Injectors.
American Injector Co., Detroit, Mich.
Detroit Lubricator Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, Ohio.
Wm. Sellers & Co., Philadelphia, Pa.

Industrial Railways.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

Insulated Wire.
Okonite Co., Ltd., 253 Broadway, New York.

Iron.
Passaic Rolling Mill Co., Passaic, N. J.

Joists, Iron and Steel.
Chester B. Albree, Allegheny, Pa.
Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.

Kiers.
Atlantic Works, East Boston, Mass.

For Alphabetical Index to Advertisers, see page 23.

Kyanizing.
Otis Allen & Son, Lowell, Mass.

Lamps, Electric.
Fort Wayne Electric Corporation, Fort Wayne, Ind.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Lathes.
W. F. & John Barnes Co., Rockford, Ill.
Bement, Miles & Co., Philadelphia, Pa.
E. W. Bliss Co., Brooklyn, N. Y.
Bradford Mill Co., Cincinnati, Ohio.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Gleason Tool Co., 4 Race St., Rochester, N. Y.
Hamilton Machine Tool Co., Hamilton, Ohio.
Jones & Lamson Machine Co., Springfield, Vt.
Montgomery Company, 105 Fulton St., New York.
Niles Tool Works, Hamilton, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Launches—Steam, Naphtha, etc.
Gas Engine & Power Co., Morris Heights New York City.
Marine Iron Works, Station A, Chicago, Ill.
Charles L. Seabury & Co., Morris Heights, New York City.

Link Belting.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.

Locomotives.
Baldwin Locomotive Works, Philadelphia, Pa.
John F. Byers Machine Co., Ravenna, Ohio.
Pittsburg Locomotive Works, Pittsburg, Pa.
H. K. Porter & Co., Pittsburg, Pa.
Stearns Manufacturing Co., Erie, Pa.

Locomotive Brakes.
Westinghouse Air Brake Co., Pittsburg, Pa.

Locomotive Cranes.
Bucyrus Co., So. Milwaukee, Wis.

Lubricants.
Jos. Dixon Crucible Co., Jersey City, N. J.

Lubricators.
Detroit Lubricator Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, Ohio.

Machine Screws.
Worcester Machine Screw Co., Worcester, Mass.

Machine Tools and Supplies.
Acme Machinery Co., Cleveland, Ohio.
W. F. & John Barnes Co., Rockford, Ill.
Bement, Miles & Co., Philadelphia, Pa.
Billings & Spencer Co., Hartford, Conn.
E. W. Bliss Co., Brooklyn, N. Y.
Bradford Mill Co., Cincinnati, Ohio.
Chicago Flexible Shaft Co., Chicago, Ill.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Gleason Tool Co., 4 Race St., Rochester, N. Y.
Hammacher, Schlemmer & Co., 209 Bowery, N. Y.
Hilles & Jones Co , Wilmington, Del.
Jones & Lamson Machine Co., Springfield, Vt.
Hamilton Machine Tool Co., Hamilton, Ohio.
Montgomery Co., 105 Fulton St., New York.
Niles Tool Works, Hamilton, Ohio.
Q & C Company, Ch cago, Ill.
Wm. Sellers & Co., Philadelphia, Pa.
Stearns Manufacturing Co., Erie, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Walworth Manufacturing Co., Boston, Mass.
Worcester Machine Screw Co., Worcester, Mass.

Marine Machinery.
Gas Engine & Power Co., Morris Heights, New York City.
Lambert Hoisting Engine Co., Newark, N. J.
Marine Iron Works, Station A, Chicago, Ill.
Charles L. Seabury & Co., Morris Heights, New York City.

Mathematical Instruments.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.,
Queen & Co., Inc., Philadelphia, Pa.

Mechanical Draft.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Merchant Steel.
Wm. Jessop & Sons, Ltd., 91 John St., New York.

Metals.
Wm. Jessop & Sons, Ltd., 91 John St., New York.
Passaic Rolling Mill Co., Paterson, N. J.
Phosphor Bronze Smelting Co., Ltd., Phila., Pa.

Metal Lath.
Cincinnati Corrugating Co., Piqua, Ohio.

Metal Punching and Shearing.
Harrington & King Perforating Co., Chicago, Ill.

Meters, Electric.
Ft. Wayne Electric Corporation, Ft. Wayne, Ind.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Weston Electrical Instrument Co., Newark, N. J.

Milling Machines.
Bement, Miles & Co., Philadelphia, Pa.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Hilles & Jones Co., Wilmington, Del.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Mine Cars.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

Mining Machinery.
Edw. P. Allis Co., So. Milwaukee, Wis.
American Hoist & Derrick Co., St. Paul, Minn.
Bradley Pulverizer Co., Boston, Mass.
A. S. Cameron Steam Pump Works, E. 23d St., N. Y.
Chrome Steel Works, Brooklyn, N. Y.
W. J. Clark & Co., Salem, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeffrey Mfg. Co., Columbus, Ohio.
Arthur Koppel, 68 Broad St., New York.
Lambert Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
John H. McGowan Co., Cincinnati, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, New York.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.
Webster, Camp & Lane Machine Co., Akron, Ohio.
Westinghouse Electric & Mfg Co., Pittsburg, Pa.

Mining Screens.
Fraser & Chalmers, Chicago, Ill.

For Alphabetical Index to Advertisers, see page 23.

Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.

Motors, Electric.
American Engine Co., Bound Brook, N. J.
H. B. Coho & Co., New York.
Ft. Wayne Electric Corporation, Ft. Wayne, Ind.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Keystone Electric Co., Erie, Pa.
B. F. Sturtevant Co., Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Naphtha Gas Machines.
American Gas Furnace Co., 23 John St., New York.

Nickel.
Canadian Copper Co., Cleveland, Ohio.
Orford Copper Co., 37 Wall St., New York.

Office Furniture.
Globe Company, Cincinnati, Ohio.

Oil Cups.
Detroit Lubricator Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, Ohio.
Montgomery Company, 105 Fulton St., N. Y.
Walworth Manufacturing Co., Boston, Mass.

Oil-Gas Plants.
American Gas Furnace Co., 23 John St., New York.

Oil Separators.
A. A. Griffing Iron Co., 66-68 Center St., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.

Open Links.
Keystone Drop Forge Co., Philadelphia, Pa.

Ordnance Forgings.
J. H. Williams & Co., Brooklyn, N. Y.

Ore-Dressing Machinery.
Fraser & Chalmers, Chicago, Ill.

Ore-Roasting Machinery.
F. D. Cummer & Son Co., Cleveland, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Ornamental Iron Work.
Chester B. Albree, Allegheny, Pa.
Winslow Bros. Co., Chicago, Ill.

Packing.
Boston Belting Co., Boston, Mass.
Jenkins Brothers, 71 John St., New York.
Montgomery Co., 105 Fulton St., New York.
New York Belting & Packing Co., Ltd., New York.
Peerless Rubber Mfg. Co., 16 Warren St., New York.

Paddle-Wheel Machinery.
Marine Iron Works, Station A, Chicago, Ill.

Paints.
Detroit Graphite Mfg. Co., Detroit, Mich.
Joseph Dixon Crucible Co., Jersey City, N. J.

Paints for Iron and Steel.
W. W. Lawrence & Co., Pittsburg, Pa.

Paper-Mill Machinery.
Jeffrey Mfg. Co., Columbus, Ohio.
Robt. Wetherill & Co., Chester, Pa.

Pattern-Makers' Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.

Penstocks.
Atlantic Works, East Boston, Mass.

Perforated Metals.
Fraser & Chalmers, Chicago, Ill.

Peroxide of Sodium.
Roessler & Hasslacher Chemical Co., New York.

Phosphor Bronze.
Phosphor Bronze Smelting Co., Ltd., Phila., Pa.

Photographic Supplies.
Queen & Co., Inc., Philadelphia, Pa.

Pile Drivers.
Bucyrus Co., So. Milwaukee, Wis.

Pipe, Cast Iron.
Jeanesville Iron Works, Jeanesville, Pa.
McNeal Pipe & Foundry Co., Burlington, N. J.
Ohio Pipe Co., Columbus, Ohio.
Walworth Manufacturing Co., Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Pipe, Coverings.
Michigan Pipe Co., Bay City, Mich.

Pipe-Cutting and -Threading Machines.
Armstrong Mfg. Co., Bridgeport, Conn.
Walworth Manufacturing Co., Boston, Mass.

Pipe Dies.
Walworth Manufacturing Co., Boston, Mass.

Pipe Fittings, Cast-Iron.
Walworth Manufacturing Co., Boston, Mass.

Pipe, Wrought-Iron.
Walworth Manufacturing Co., Boston, Mass.

Placer Mining Machinery.
Bucyrus Co., So. Milwaukee, Wis.

Planers.
Bement, Miles & Co., Philadelphia, Pa.
Hilles & Jones Co., Wilmington, Del.
Wm. Sellers & Co., Inc., Philadelphta, Pa.

Planing Mill Machinery.
Egan Co., Cincinnati, Ohio.
J. A. Fay & Co., Cincinnati, Ohio.

Plumbers' Tools and Supplies.
Walworth Manufacturing Co., Boston, Mass.

Portable Railways.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

Portland Cement.
Atlas Cement Co., 143 Liberty St., New York.

Power Hammers.
Bement, Miles & Co., Philadelphia, Pa.
E. W. Bliss Co., Brooklyn, N. Y.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Power Punches and Shears.
E. W. Bliss Co., Brooklyn, N. Y.
Hilles & Jones Co., Wilmington, Del.
Montgomery Company, 105 Fulton St., New York.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Power-Transmission Machinery.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

For Alphabetical Index to Advertisers, see page 23.

Preservation of Lumber.
Otis Allen & Son, Lowell, Mass.

Presses, Hydraulic, etc.
Ferracute Machine Co., Bridgeton, N. J.
Niles Tool Works, Hamilton, Ohio.
Watson & Stillman Co., 210 E. 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

Printers Supplies.
Heber Wells, New York.

Prospecting Drills.
American Well Works, Aurora, Ill.
Star Drilling Machine Co., Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Pulley Covers.
Shultz Belting Co., St. Louis, Mo.

Pulleys, Shafting and Hangers.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Montgomery Company, 105 Fulton St., New York.
Reeves Pulley Co., Columbus, Indiana.
Wm. Sellers & Co., Philadelphia, Pa.
Robert Wetherill & Co., Chester, Pa.

Pulverizers.
Bradley Pulverizer Co., Boston, Mass.
Fraser & Chalmers, Chicago, Ill.
Stedman's Foundry & Machine Co., Aurora, Ind.

Pumps and Pumping Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
American Well Works, Aurora, Ill.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Deane Steam Pump Co., Holyoke, Mass.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
A. A. Griffing Iron Co., 66 68 Center St., New York.
Guild & Garrison, Brooklyn, N. Y.
Hall Steam Pump Co., Pittsburg, Pa.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Jeanesvi le Iron Works, Jeanesville, Pa.
Laidlaw-Dunn-Gordon Co., Cincinnati, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Odorless Excavating Co., Boston, Mass.
Pulsometer Steam Pump Co., 120 Liberty St., N. Y.
Wm. E. Quimby, 86 Broad St., New York.
Snow Steam Pump Works, Buffalo, N. Y.
Stillwell-Bierce & Smith-Vaile Co., Dayton, Ohio.
Webster, Camp & Lane Machine Co., Akron, Ohio.
R. D. Wood & Co,. Philadelphia, Pa.

Punching and Shearing Machinery.
Bement, Miles & Co., Philadelphia, Pa.
Hilles & Jones Co., Wilmington, Del.
Long & Allstatter Co., Hamilton, Ohio.
New Doty Manufacturing Co., Janesville, Wis.

Quarrying Machinery.
American Hoist & Derrick Co., St. Paul, Minn.
John F. Byers Machine Co., Ravenna, Ohio.
A. S. Cameron Steam Pump Works, E. 23d St., N.Y.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y
Rand Drill Co., 100 Broadway, New York.
John H. McGowan Co., Cincinnati, Ohio.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.

Radiator Screens.
Harrington & King Perforating Co., Chicago, Ill.

Radiators.
H. B Smith Co., 137 Center St., New York.

Railroad Ditchers.
Jeffrey Mfg. Co., Cleveland, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Railway-Car Brakes.
Westinghouse Air Brake Co., Pittsburg, Pa.

Railway Feed Wires.
Okonite Co., Ltd., 253 Broadway, New York.

Railway Shop Machinery.
Chester B. Albree, Allegheny, Pa.
Armstrong Mfg. Co., Bridgeport, Conn.
W. F. & John Barnes Co., Rockford, Ill.
Bradford Mill Co., Cincinnati, Ohio.
Chicago Flexible Shaft Co , Chicago, Ill.
Egan Co., Cincinnati, Ohio.
J. A Fay & Co., Cincinnati, Ohio.
Hilles & Jones Co., Wilmington, Del.
Niles Tool Works, Hamilton, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Q & C Co., Chicago, Ill.
Stow Flexible Shaft Co., Philadelphia, Pa
Stow Manufacturing Co , Binghamton, N. Y.
Watson & Stillman Co., 210 E. 43d St., New York.

Railway Specialties.
Arthur Koppel, 68 Broad St., New York.
H. K. Porter & Co., Pittsburg, Pa.
Q & C Co., Chicago., Ill.
Westinghouse Air Brake Co., Pittsburg, Pa.

Railways, Portable.
C. W. Hunt Co., 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

Rawhide Pinions.
New Process Rawhide Co., Syracuse, N. Y.

Reducing Valves.
Ross Valve Co., Troy, N. Y.
Waters Governor Co., 34 Oliver St., Boston, Mass.

Refrigerating Machinery.
Frick Company, Waynesboro, Pa.
Vilter Manufacturing Co., Milwaukee, Wis.

Riveting Machines.
Chester B. Albree, Allegheny, Pa.
Montgomery Company, 105 Fulton St., N. Y.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Road-Making Machinery.
O. S. Kelly Co., Springfield, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Road Rollers.
O. S. Kelly Co., Springfield, Ohio.

Rock Breakers.
Edw. P. Allis Co., Milwaukee, Wis.
Bradley Pulverizer Co., Boston, Mass.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Rock Drills.
American Hoist & Derrick Co., St. Paul, Minn.
M. C. Bullock Mfg. Co., Chicago, Ill.

For Alphabetical Index to Advertisers, see page 23.

STACKPOLE & BROTHER,
Manufacturers of
SURVEYING INSTRUMENTS.
Repairing a Specialty.
42 FULTON ST., NEW YORK.
Send for Circular.

THE BRANDIS SONS CO.,
Surveying and Engineering Instruments
754 to 756 LEXINGTON AVENUE,
Catalogues sent on application. BROOKLYN, N. Y.

$\sqrt[5]{\frac{324 \times 217^3 \times \text{VERS } 31^m\ 32'\ 40''}{14.25^3 \times 2.37^2}} = 2.7185$

SOLVED ON THE "OMNIMETRE" WITHOUT THE AID OF TABLES.

THEO. ALTENEDER & SONS
PHILADELPHIA.

THE ENGINEERING INDEX places the contents of any Engineering paper in English. French or German before the engineer each month, and furnishes a means of getting quickly any particular article desired.

WEST AND SOUTH

run the lines of the Illinois Central Railroad and the Yazoo & Mississippi Valley Railroad, reaching into the eleven States of

South Dakota	Kentucky
Minnesota	Tennessee
Iowa	Arkansas
Wisconsin	Mississippi
Illinois Indiana	Louisiana

Presenting an unequaled territory for diversified industries, and possessing

Fine Sites for New Mills
Best of Freight Facilities---Coal Fields
Close Proximity to Distributing Centers
Intelligent Help of all Kinds
Many Kinds of Raw Material

To sound industries, substantial inducements will be given by many of the places concisely described in the pamphlet "100 Cities and Towns Wanting Industries." Write for a copy. Nearly all kinds of industries are wanted. Very liberal inducements are offered **TEXTILE INDUSTRIES** in the South by a number of good places. GEORGE C. POWER, Industrial Commissioner I. C. R. R. Co., Chicago. I. 2-97.

THE UNITED GAS IMPROVEMENT CO.
DREXEL BUILDING, PHILADELPHIA, PA.
BUILDERS OF
The Standard Lowe . . .
. . Water Gas Apparatus.

INJUNCTIONS

Throughout the United States have been granted me against the **New York Dredging Co., A. W. Von Schmidt, Williams & Bixler, The Golden State & Miners Iron Works,** the **McNee Bros., John Hackett, The Pacific Coast Dredging and Reclamation Co.**; and also against the **SAN FRANCISCO BRIDGE CO.,** in the States of Washington and Oregon.

I have 12 Letters Patent of my own with **389 claims,** and **18 others—30** in all having an aggregate of **452 claims,** covering, it is thought, **everything of practical utility in hydraulic dredging.**

All persons are cautioned against making, using, buying except from me, or selling infringing machines, as I shall protect my rights to the full extent of the law.

Unlimited Contracts for Dredging and Filling, taken in any part of the World.

A. B. BOWERS, CONTRACTOR, INVENTOR, ENGINEER,
Mills Building, San Francisco, Cal.

Please mention The Engineering Magazine when you write.

Clayton Air Compressor Works, 26 Cortlandt St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., N. Y.
Rand Drill Co., 100 Broadway, New York.
Star Drilling Machine Co., Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Roller Bearings.
Hyatt Roller Bearing Co., Harrison, N. J.

Roofing.
Berlin Iron Bridge Co., East Berlin, Conn.
Cincinnati Corrugating Co., Piqua, Ohio.
Passaic Rolling Mill Co., Paterson, N. J.

Roofs, Iron Truss.
Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.

Rope Transmission.
C. W. Hunt Co., 45 Broadway, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co , Philadelphia, Pa.

Rubber Goods.
Boston Belting Co., Boston, Mass.
Jenkins Brothers, 71 John St., New York.
New York Belting & Packing Co., Ltd., New York.

Saw-Mill Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
Chandler & Taylor Co., Indianapolis, Ind.

Schools.
Bliss School of Electricity, Washington, D. C
International Correspondence Schools, Scranton, Pa.
Michigan College of Mines, Houghton, Mich.
Purdue University, Lafayette, Ind.
Rose Polytecnic Institute, Terre Haute, Ind.
Worcester Polytechnic Institute, Worcester, Mass.

Screens, Mining.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.

Screw Machines.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Jones & Lamson Machine Co., Springfield, Vt.
Montgomery Company, 105 Fulton St., New York.
Niles Tool Works, Hamilton, Ohio.

Separators, Coal and Ore.
F. D. Cummer & Son Co., Cleveland, Ohio.

Separators, Steam.
A. A. Griffing Iron Co., 66-68 Center St., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Shafting (see Pulleys).

Shaping Machines.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Sheet-Metal Tools.
E. W. Bliss Co., Brooklyn, N. Y.

Shoes and Dies.
Chrome Steel Works, Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Smokestacks.
Clonbrock Steam Boiler Co , Brooklyn, N. Y.

Sodium Peroxide.
Roessler & Hasslocher Chem. Co., 100 William St., New York.

Spark Guards, Perforated.
Harrington & King Perforating Co., Chicago, Il

Steam Loops.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Steam-Regulating Appliances.
Detroit Lubricator Co., Detroit, Mich.
Harrison Safety Boiler Works, Philadelphia, Pa.
Jenkins Brothers, 71 John St., New York.
Lunkenheimer Co., Cincinnati, Ohio.
Ross Valve Co , Troy, N. Y.
B. F. Sturtevant Co., Boston Mass.
Walworth Manufacturing Co., Boston, Mass.

Steamships and Towboats.
Atlantic Works, East Boston, Mass.

Steam Shovels.
Bucyrus Co., So. Milwaukee, Wis.
Marion Steam Shovel Co , Marion, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Steam Traps.
American Blower Co., Detroit, Mich.
American Impulse Wheel Co., 120 Liberty St., New York.
Buffalo Forge Co., Buffalo, N. Y.
A. A. Griffing Iron Co. 66-68 Center St., New York.
B. F. Sturtevant Co., Boston, Mass.
Walworth Manufacturing Co., Boston, Mass.

Steel Importers.
Hobson, Seaman & Co , 97 John St., New York.
Wm. Jessop & Sons, Ltd., 91 John St., New York.

Steel Manufacturers.
Chrome Steel Works, Brooklyn, N. Y.
Hobson, Seaman & Co., 97 John St., New York.
Wm. Jessop & Sons, Ltd., 91 John St., New York.
Passaic Rolling Mill Co., Paterson, N. J.

Stokers.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Storage Batteries.
Electric Storage Battery Co., Philadelphia, Pa.

Structural Iron Work.
Chester B. Albree, Allegheny, Pa.
Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.

Sugar-House Machinery.
Henry G. Morris, Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Surveying Instruments.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Queen & Co., Inc , Philadelphia, Pa.
Stackpole & Brother, 42 Fulton St., New York.

Tanks, Iron.
Atlantic Works, East Boston, Mass.
Clonbrock Steam Boiler Co., Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Pittsburg Locomotive Works, Pittsburg, Pa.
Taunton Locomotive Mfg. Co., Taunton, Mass.

For Alphabetical Index to Advertisers, see page 23.

Tapping and Reaming Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Telegraph Wires and Cables.
John A. Roebling's Sons Co., Trenton, N. J
Okonite Co., New York.

Testing Machinery.
Wm. Sellers & Co., Philadelphia, Pa.

Thermometers.
Bristol Co., Waterbury, Conn.
Queen & Co., Inc., Philadelphia, Pa.

Tie Plates.
Q & C Co., Chicago, Ill.

Tire-Welding Machine.
Long & Allstatter Co., Hamilton, Ohio.

Tramways.
C. W. Hunt Co , 45 Broadway, New York.
Arthur Koppel, 68 Broad St., New York.

Tramways, Wire Rope.
Cooper Hewitt & Co., 17 Burling Slip, New York.
Fraser & Chalmers, Chicago, Ill.
C. W. Hunt Co., 45 Broadway, New York.
Trenton Iron Co., Trenton, N. J.

Turbines.
James Leffel & Co., Springfield, Ohio.
Westinghouse Machine Co., Pittsburg, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Turn-Tables.
Passaic Rolling Mill Co., Paterson, N. J.
Wm Sellers & Co , Philadelphia, Pa.

Twist Drills.
Cleveland Twist Drill Co , Cleveland, Ohio.
Montgomery Company, 105 Fulton St., New York.
Standard Tool Co., Cleveland, Ohio.

Vacuum Pans.
Henry G. Morris, Philadelphia, Pa.

Vacuum Pumps.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Clayton Air Compressor Works, 26 Cortlandt St , New York.
Deane Steam Pump Co., Holyoke, Mass.
Guild & Garrison, Brooklyn, N. Y.
John H. McGowan Co., Cincinnati, Ohio.

Valves—Gas, Steam, and Water.
Detroit Lubricator Co., Detroit, Mich.
Jeanesville Iron Works, Jeanesville, Pa.
Jenkins Brothers, 71 John St., New York.
Lunkenheimer Co., Cincinnati, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Montgomery Company, 105 Fulton St., New York.
Ross Valve Co., Troy, N. Y.
Walworth Mfg. Co , Boston, Mass.
Waters Governor Co., 34 Oliver St , Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Ventilating Appliances.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
B. F. Sturtevant Co., Boston, Mass.

Voltmeters.
Ft. Wayne Electric Corporation, Ft. Wayne, Ind.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Weston Electrical Instrument Co., Newark, N. J.

Water Columns (Safety).
A. A. Griffing Iron Co., 66-68 Center St., New York.

Water Meters.
Buffalo Meter Co., Buffalo, N. Y.
Pittsburg Meter Co., East Pittsburg, Pa.

Water-Works Supplies.
American Well Works, Aurora, Ill.
McNeal Pipe & Foundry Co., Burlington, N. J.
Star Drilling Machine Co., Akron, Ohio.

Water Wheels.
James Leffel & Co., Springfield, Ohio.
R. D. Wood & Co., Philadelphia, Pa.

Water-Works Pumping Machinery.
Fraser & Chalmers, Chicago, Ill.
John H. McGowan Co., Cincinnati, Ohio.

Well-Sinking Machinery.
American Well Works, Aurora, Ill.
Cole Brothers, 102 Fulton St., New York.
Star Drilling Machine Co , Akron, Ohio.
Williams Bros., Ithaca, N. Y.

Wire.
Phosphor Bronze Smelting Co., Ltd., Philadelphia, Pa.

Wire Cloth.
Phosphor Bronze Smelting Co., Ltd., Philadelphia, Pa.

Wire Rope.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Phosphor Bronze Smelting Co., Ltd., Philadelphia, Pa.
John A. Roebling's Sons Co., Trenton, N. J.
Trenton Iron Co., Trenton, N. J.

Wood-Working Machinery.
Egan Co., Cincinnati, Ohio.
J. A Fay & Co., Cincinnati, Ohio.
Stow Flexible Shaft Co., Philadelphia, Pa.

Worm Gears.
Morse, Williams & Co , Philadelphia, Pa.

Wrecking Cars.
Bucyrus Co., So. Milwaukee, Wis.
Marion Steam Shovel Co., Marion, Ohio.

Wrenches.
J. H. Williams & Co., Brooklyn, N. Y.

Yachts.
Atlantic Works, East Boston, Mass.
Daimler Motor Works, Steinway, Long Island City, N. Y.

For Alphabetical Index to Advertisers, see page 23.

JULIAN KENNEDY,

Consulting and Contracting Engineer,

Vandegrift Building, Pittsburgh, Pa.

BLAST FURNACES, BESSEMER AND OPEN HEARTH STEEL WORKS, ROLLING MILLS, STEAM AND HYDRAULIC MACHINERY, HEATING FURNACES, GAS PRODUCERS, &c.

Branch Office of the LATROBE STEEL WORKS.

SYDNEY F. REYNOLDS, Torrey, Pa.

Architect, Builder, Draughtsman, Electrical, Mechanical, Mining and Civil Engineer.

ALL WORK GUARANTEED.

H. B. ROELKER,

41 MAIDEN LANE, NEW YORK.

Consulting, Expert and Constructing Mechanical Engineer, on Factory and Marine Work, refrigerating and pumping machinery. Designer and manufacturer of screw propellers. The Allen dense air ice machine for steam vessels.

Alton D. Adams, M.A.I.E.E.

ELECTRICAL ENGINEER,

ELECTRIC POWER TRANSMISSION AND MACHINERY.

No. 620 Atlantic Ave., BOSTON, MASS.

BLOOD & HALE,

CONSULTING AND DESIGNING ENGINEERS.

Experts on Elevated and Heavy Electric Traction Complete designs furnished for electrical and mechanical apparatus.

Plans and Specifications furnished for Power Plants.

EQUITABLE BLDG., BOSTON.

WM. O. WEBBER, A.S.M.E., CON ENG.,

509 Exchange Building, 53 State St., BOSTON, MASS.

Power Plants and Factories, Steam Expert, Electric Transmission of Power, Shop Methods and Production, Power Tests, Hydraulic Engineering.

CENTURY ENGINEERING CO.,

Contracting and Consulting Engineers,

311 Century Bldg., **CLEVELAND, OHIO.**

Electric Railways, Electric Light Plants, Power Plants, Steam Roads, Plans, Specifications, Estimates, Tests, Supervision

---

ESTABLISHED IN 1864.

W. C. DODGE,

ATTORNEY AND SOLICITOR OF PATENTS,

No. 700 NINTH ST., COR. OF G,

WASHINGTON, D. C.

OPINIONS AS TO INFRINGEMENTS, AND ALL BUSINESS RELATING TO PATENTS PROMPTLY ATTENDED TO.

C. L. REDFIELD, M. E.

DESIGNER OF MACHINERY,

EXPERT IN PATENT CAUSES.

269 Dearborn Street, CHICAGO, ILL.

W. DUSEDAU,

CONSULTING AND CONTRACTING ENGINEER,

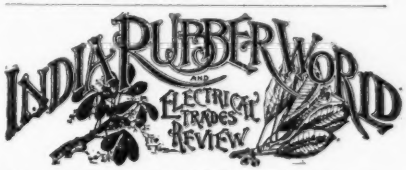
161 Barbey Street, Brooklyn, N. Y.

CABLE ADDRESS: DUSEDAU, BROOKLYN.

SPECIALTIES:

AERIAL WIRE ROPEWAYS, HOISTING AND CONVEYING CABLEWAYS, PLANS, SPECIFICATIONS AND ESTIMATES FURNISHED. COMPLETE LINES BUILT AND SUCCESSFULLY OPERATED.

12 YEARS' PRACTICAL EXPERIENCE. Correspondence Solicited.



SUBSCRIPTION $3 A YEAR.

The only publication in the United States devoted exclusively to the Rubber Trade.

The India Rubber Publishing Co.,

120-122 LIBERTY STREET,

NEW YORK, U. S. A.

COMPRESSED AIR

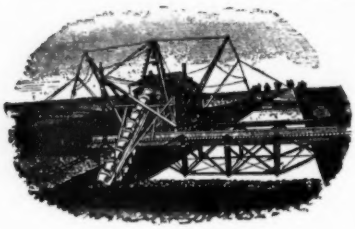
Published monthly. Now in its third year. The only periodical devoted exclusively to this subject. It is both theoretical and practical, progressive and up-to-date. Subscription $1.0 a year. Foreign, $1 50. Send for sample copy.

COMPRESSED AIR, 26 Cortlandt St., N.Y.

Please menti.n The Engineering Magazine when you write.

New York Dredging Co.,

Hydraulic Dredge discharging through 5,700 Ft. Pipe. Will dig and put ashore any material. Rock excepted.



Patent Canal Excavator.

Engineers and Contractors.

GEO. W. CATT, M. Am. Soc. C. E., President and Engineer.
O. L. WILLIAMS, Secretary and Treasurer.

SPECIALTIES:

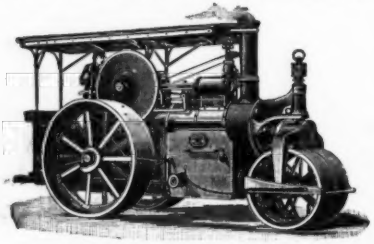
Machinery for Economical Excavation of Canals, For Dredging, For Reclamation of Low Lands.

Correspondence Solicited.

Machines at work at League Island, Philadelphia, Pa.; Port Royal, S. C.; Port Arthur, Sabine Pass, Tex.; and Oakland, Cal.

World Building, - - NEW YORK.

THE O. S. KELLY CO., SPRINGFIELD, OHIO, U. S. A.



STEAM ROAD ROLLERS,
STEAM ASPHALT ROLLERS,
STEAM GOLF LINKS ROLLERS,
OVERLAND FREIGHTING OUTFITS,
PICK-UP STREET SWEEPERS.

- - - SEND FOR CATALOGUES.

BOSTON-1053 EXCHANGE BLDG CHICAGO-1105 MONADNOCK BLOCK.

SAN FRANCISCO-32 FIRST ST.

GREEN'S ECONOMIZER

THE FUEL Steam Fuel ECONOMIZER Co.

MATTEAWAN, N.Y.

CORRESPONDENCE SOLICITED.

HEAD OFFICE & WORKS-MATTEAWAN, N.Y. NEW YORK CITY-74 CORTLANDT.

MONTREAL-54 STREET R.R. CHAMBERS.

Please mention The Engineering Magazine when you write.

ALPHABETICAL INDEX TO ADVERTISERS.

Acme Machinery Co 56
Adams, Alton D..... 21
Albree, Chester B..... 61
Allen & Son, Otis..... 71
Allis Co., Edw. P..... 52
Almy Water-Tube Boiler Co 50
Alteneder & Sons, Theo 18
American Blower Co..... 71
American Engine Co..... 50
American Gas Furnace Co..... 48
American Hoist & Derrick Co 35
American Injector Co..... 8
American Well Works..... 40
Armstrong Mfg. Co..... 74
Atlantic Works 70
Atlas Cement Co..... 7

Baldwin Locomotive Works..... 41
Baragwanath & Son, Wm..... 49
Barnes Co., W. F. & John..... 55
Bement, Miles & Co..... 55
Berlin Iron Bridge Co..... 71
"Big Four" Route..... 54
Bilgram, Hugo 60
Billings & Spencer Co..... 8
Bliss Co., E. W..... 62
Bliss School of Electricity..... 25
Blood & Hale 21
Boston Belting Co. 63
Bowers, A. B 18
Bradford Mill Co 56
Bradley Pulverizer Co..... 33
Brandis Sons Co..... 18
Bristol Company..... 76
Brooks & Co., T. H 72
Broomell, Schmidt & Co..... 57
Brown Hoisting & Conveying Machine Co 39
Bucyrus Co 3
Buffalo Forge Co..... 26
Buffalo Meter Co..... 32
Bullock Mfg. Co., M. C..... 38
Byers Machine Co., John F..... 32

Cameron Steam Pump Works, A. S..... 31
Canadian Copper Co..... 8
Carborundum Co..... 65
Central Fire-Proofing Co..... 72
Century Engineering Co..... 21
Chandler & Taylor Co..... 47
Chicago Flexible Shaft Co..... 64
Chrome Steel Works..... 74
Churchill & Co., Chas..... 66
Cincinnati Corrugating Co..... 4
Cincinnati Milling Machine Co..... 59
Clark & Co., W. J..... 32
Clayton Air Compressor Works..... 3
Clonbrock Steam Boiler Co 60
Coho & Co., H. B..... 68
Cole Brothers 68
"Compressed Air"..... 21
Comstock, Wm. T..... 25
Contractors' Plant Mfg. Co..... 37
Cooper, Hewitt & Co..... 36
Cummer & Son Co., F. D..... 49

Daimler Motor Works..... 46
Deane Steam Pump Co..... 30
Dearborn Drug & Chemical Works..... 53
Detroit Graphite Mfg Co..... 26
Detroit Lubricator Co 46
Direct Separator Co..... 46
Dixon Crucible Co., Joseph 7
Dodge, W. C 21
Dusedau, W 21

Eastern Machinery Co 67
Electric Storage Battery Co..... 4

Fay & Co., J. A..... 60
Felt & Tarrant Mfg. Co 54
Ferracute Machine Co..... 62
Flagg & Co., Stanley G 76
Fort Wayne Electric Corporation..... 68
Fraser & Chalmers 34
Frick Company..... 47
Fuel Economizer Co..... 22

Gates Iron Works..... 34
General Electric Co..... 25
Gleason Tool Co..... 76
Globe Company..... 40
Gorton & Lidgerwood Co..... 74
Griffing Iron Co., A. A..... 49
Guild & Garrison 75

Hall Steam Pump Co 30
Hammacher, Schlemmer & Co..... 65
Harrison Safety Boiler Works..... 52
Hartford Steam Boiler Inspection and Ins. Co..... 8
Hazelton Boiler Co 29
Hilles & Jones Co..... 7
Hobson, Seaman & Co..... 59
Hooven, Owens & Rentschler Co..... 47
Hoppes Mfg. Co..... 49
Hunt Co., C. W..... 44
Hyatt Roller Bearing Co..... 55

Ide & Sons, A. L..... 45
Illinois Central R. R..... 18
India Rubber World..... 21
Ingersoll-Sergeant Drill Co..... 33
International Correspondence Schools 25

Jeanesville Iron Works..... 30
Jeffrey Mfg. Co..... 37
Jenkins Bros..... 76
Jessop & Sons, Ltd., William..... 59
Johns Mfg. Co., H. W 72
Jones & Lamson Machine Co..... 60

Kelly Co., O. S..... 22
Kennedy, Julian..... 21
Keystone Drop Forge Co 4
Keystone Electric Co..... 68

ALPHABETICAL INDEX

Koppel, Arthur ... 61

Laidlaw-Dunn-Gordon Co ... 31
Lambert Hoisting Engine Co ... 75
Landis Tool Co ... 67
Lawrence & Co., W. W ... 73
Leffel & Co., James ... 2
Lidgerwood Mfg. Co ... 2
Link-Belt Engineering Co ... 36
Long & Alstatter Co ... 62
Lunkenheimer Co ... 76

McCabe Hanger Mfg. Co ... 71
McGowan Co., John H ... 32
McNeal Pipe & Foundry Co ... 64
Main Belting Co ... 66
Manufacturers' Advertising Bureau ... 75
Marine Iron Works ... 46
Marion Steam Shovel Co ... 3
Maurer & Son, Henry ... 72
Michigan College of Mines ... 25
Michigan Pipe Co ... 32
Monon Route ... 54
Montgomery & Co ... 65
Morris, Henry G ... 7
Morse, Williams & Co ... 60

New Doty Manufacturing Co ... 59
New Process Raw Hide Co ... 66
New York Air Brake Co ... 42 & 43
N. Y. Central & H. R. R. R ... 54
New York Dredging Co ... 22
New York Filter Mfg. Co ... 4
Nicholson File Co ... 55
Niles Tool Works Co ... 61
North American Metaline Co ... 55
Norwalk Iron Works ... 35

Odorless Excavating Co ... 36
Ohio Pipe Co ... 64
Okonite Co., Ltd ... 29
Orford Copper Co ... 8
Otto Gas Engine Works ... 50

Passaic Rolling Mill Co ... 26
Peerless Rubber Mfg. Co ... 3
Penberthy Injector Co ... 48
Phosphor Bronze Smelting Co., Ltd ... 59
Pittsburg Locomotive Works ... 41
Pittsburg Meter Co ... 32
Pittsburg Terra Cotta Lumber Co ... 72
Porter & Co., H. K ... 41
Pratt & Whitney Co ... 70
Pulsometer Steam Pump Co ... 30
Purdue University ... 25

Q & C Company ... 3
Queen & Co., Inc ... 7
Quimby, Wm. E ... 74

Rand Drill Co ... 34
Reeves Pulley Co ... 67
Redfield, C. L ... 21
Reynolds, Sydney F ... 21
Rife Engine Co ... 50
Robins Conveying Belt Co ... 35
Roebling's Sons Co., John A ... 36
Roelker, H. B ... 21
Roessler & Hasslacher Chem. Co ... 32
Rose Polytechnic Institute ... 25
Ross Valve Co ... 41

Saginaw Mfg. Co ... 67
Sellers & Co., Wm ... 70
Smith Co., H. B ... 73
Snow Steam Pump Works ... 31
Sprague Electric Co ... 69
Stackpole & Brother ... 18
Star Drilling Machine Co ... 40
Stearns Manufacturing Co ... 48
Stedman's Foundry & Mch. Co ... 38
Stillwell-Bierce & Smith-Vaile Co ... 31
Stow Flexible Shaft Co ... 47
Stow Manufacturing Co ... 61
Strieby & Foote Co ... 64
Sturtevant Co., B. F ... 69
Sullivan Machinery Co ... 39

Taunton Locomotive Manufacturing Co ... 48
Thorpe, Platt & Co ... 70
Trenton Iron Co ... 36
Triumph Electric Co ... 69
Turri & Co., G. G ... 45

United Gas Improvement Co ... 18

Vilter Manufacturing Co ... 50
Vulcan Iron Works ... 4

Walworth Manufacturing Co ... 7
Waters Governor Co ... 47
Watson-Stillman Co ... 62
Webber, Wm O ... 21
Webster, Camp & Lane Machine Co ... 35
Wells, Heber ... 54
Westinghouse Air Brake Co ... 41
Westinghouse Church, Kerr & Co ... 51
Westinghouse Electric & Mfg. Co ... 68
Westinghouse Machine Co ... 51
Weston Electrical Instrument Co ... 29
Wetherill & Co., Robt ... 26
Wiley & Sons, John ... 8
Williams Bros ... 40
Williams & Co., J. H ... 76
Winslow Bros. Co ... 73
Wood & Co., R. D ... 65
Worcester Machine Screw Co ... 56
Worcester Polytechnic Institute ... 25

GENERAL ELECTRIC COMPANY,

SCHENECTADY, N. Y.

Sales Offices in all Large Cities of the United States.

Builds and Guarantees Electrical Apparatus for all Lighting, Railway Power, Mining and Marine Work.

THE STANDARD ELECTRICAL APPARATUS OF THE WORLD.

Mills, Factories, Mines and Ships fully equipped Electrically.

Power Transmitted Long Distances.

Purdue University.

LAFAYETTE, INDIANA.

Courses in

Civil Engineering,
Mechanical Engineering,
Electrical Engineering.

Extensive Laboratories. Fine Equipments.

Catalogue sent on application.

MICHIGAN COLLEGE OF MINES.

Supported by the State of Michigan. Practical work. Elective system. Special advantages for men of age and experience. For catalogues address DR. M. E. WADSWORTH, President, Houghton, Michigan.

The Bliss School of Electricity,

BLISS BUILDING, WASHINGTON, D. C.

The only institution in the country teaching practical Electrical Engineering exclusively. Excellent Laboratory equipment. Instructors the best. Catalog on application.

LOUIS D. BLISS, PRESIDENT.

The Worcester Polytechnic Institute,

WORCESTER, MASS.

T. C. MENDENHALL, President.

Courses of study in Mechanical, Civil and Electrical Engineering, Chemistry and General Science. New and extensive laboratories in Engineering, Electricity, Physics and Chemistry. Special facilities in Steam and Hydraulics. **194-page Catalogue,** showing positions filled by graduates, *mailed free.* Address J. K. MARSHALL, Registrar.

INDIANA, Terra Haute.

Rose Polytechnic Institute. A College of Engineering. Mechanical, Electrical, Civil Engineering; Chemical Courses; Architecture. Extensive shops. Modernly equipped laboratories in all depts. Expenses low. 16th year. For catalogue address C. L. MEES, President.

TECHNICAL EDUCATION 50 CENTS A WEEK

For $2 down and $2 a month, we give AN EDUCATION in:

CIVIL ENGINEERING

Steam Engineering; Electrical or Mechanical Engineering; Refrigeration; Chemistry; Mining; Architectural, or Mechanical Drawing; Surveying and Mapping; Sanitary Plumbing; Architecture; Sheet Metal Pattern Drafting; Prospecting; Bookkeeping; Shorthand; English Branches.

All who ...study **GUARANTEED SUCCESS.**

We have helped thousands to better positions.
Circular Free; State subject you wish to Study.
International Correspondence Schools, Box 813, Scranton, Pa.

AMERICAN SUPREMACY

in Applied Mechanics by Coleman Sellers.

A comprehensive review (illustrated) of the causes, conditions, and results of American progress in mechanics as compared with other nations.

12mo. Cloth, 50 Cents.

ENGINEERING MAGAZINE, New York.

DISCOUNTS Lowest Cash Discounts allowed on Architectural, Scientific, Electrical, Mechanical, Industrial and Technical Books. Catalogue and Discount Sheet Free.

WILLIAM T. COMSTOCK.
23 Warren St., New York.

Please mention The Engineering Magazine when you write.

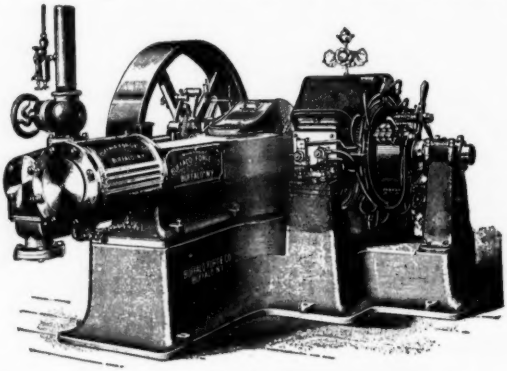
BUFFALO FORGE COMPANY ENGINE,

FOR SELECT SERVICE.

Direct Connected and Belted Types.

Refinement of Regulation, Simplicity of Design, Superiority of Construction,

There are Marine Types too.



Buffalo Forge Company, Buffalo, N. Y., U S A. NEW YORK, CHICAGO, PHILADELPHIA, PITTSBURGH.

N. Y. Office, 45 Broadway. **THE PASSAIC ROLLING MILL CO.** Main Office and Works, Paterson, N. J.

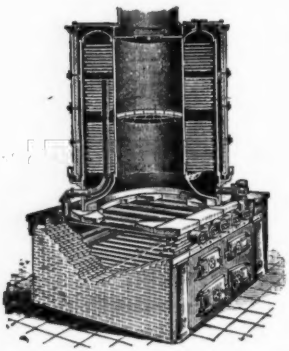
WATTS COOKE, Pres. W. O. FAYERWEATHER, V. P. & Treas. G. H. BLAKELEY, Ch Eng.

Design, Manufacture and onstruct all kinds of Iron and Steel Work for

BRIDGES AND BUILDINGS,

Roofs, Power Stations, Train Sheds, Railway and Highway Bridges and Viaducts, Standard Railroad Turntables and Structural Steel Work for Buildings. Plans and Specifications furnished upon application.

MANUFACTURERS OF HIGH GRADE IRON, OPEN HEARTH STEEL AND STRUCTURAL SHAPES.



Berry Safety Boiler.

Economizes space, fuel, maintenance and first cost to a greater degree than any other boiler. Combines simplicity and durability. Estimates and catalogue upon application.

Robert Wetherill & Co.

CHESTER, PA.

CORLISS ENGINE BUILDERS.

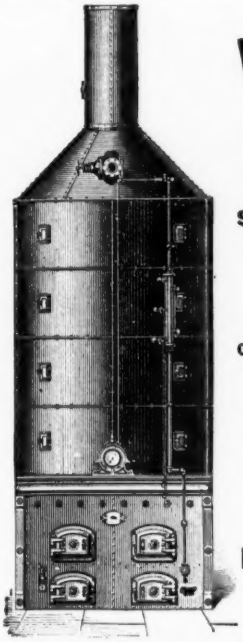
SUPERIOR Graphite Paint

For BRIDGES, ROOFS, STRUCTURAL IRON, and all Exposed Metal or Wood Surfaces.

Warranted not affected by heat, cold, salt brine, acid fumes, smoke or chemicals.

Detroit Graphite Mfg. Co., DETROIT, MICH.

Please mention The Engineering Magazine when you write.



HIGH-PRESSURE

WATER-TUBE BOILERS.

THE HAZELTON OR PORCUPINE BOILER

IN 50 to 500 H. P. UNITS.

SINGLE BOILERS OR COMPACT BATTERIES.
GREAT SAVING OF FLOOR SPACE
AND FUEL.

LARGE-SIZE BOILERS IN STOCK.

Our new book, "The Generation of Power," will be mailed on request.

THE HAZELTON BOILER CO.

Sole Proprietors and Manufacturers.

ALSO BUILDERS OF

Stacks, Tanks and Miscellaneous Metal Work.

GENERAL OFFICE:

No. 716 E. 13th ST., New York, U.S.A.

Cable Address, "Paila," New York.
Telephone Call, 1229-18th Street, New York.

WESTON

PORTABLE
GALVANOMETER
FOR BRIDGE WORK.

VOLTMETERS, AMMETERS,
OHMMETERS,
CIRCUIT TESTERS, ETC.

WESTON ELECTRICAL INSTRUMENT CO.,

114-120 William St., Newark, N. J.

1889
Paris
Exposition
MEDAL

OKONITE
TRADE MARK.

1893
World's
Fair
MEDAL

The Standard for Rubber Insulation

Okonite Wires, Okonite Tape, Manson Tape, Candee Water-proof Wire.

SOLE MANUFACTURERS, THE OKONITE CO., Ltd.,

WILLARD L. CANDEE, H DURANT CHEEVER, GEO T. MANSON, W. H. HODGINS, *Managers. General Supt. Secretary.*

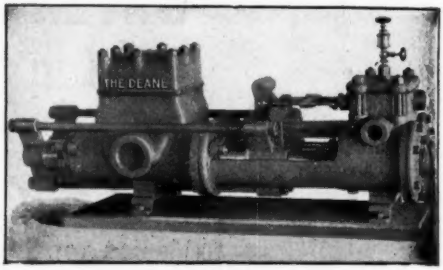
253 BROADWAY,
NEW YORK.

Please mention The Engineering Magazine when you write.

THE DEANE OF HOLYOKE.

SINGLE
DUPLEX
TRIPLEX
COMPOUND
TRIPLE EXPANSION

PUMPS.



The Deane Steam Pump Co.,
HOLYOKE, MASS.
New York. Boston. Philadelphia. Chicago.
Write for New Illustrated Catalog.

The PULSOMETER STEAM PUMP
"THE CONTRACTOR'S FRIEND."
Often Imitated—Never Equaled. Over 20,000 in Use.
RECENT IMPORTANT IMPROVEMENTS.

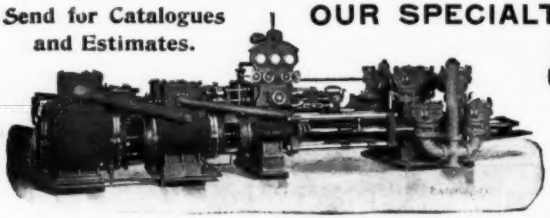
The Handiest, Simplest, and Most Efficient Steam Pump for General Mining, Quarrying, Railroad, Irrigating, Drainage, Coal-washing, Tank-filling, Paper Mill, Sewer and Bridge Contractors' Purposes, etc., etc. Muddy or gritty liquids handled without injury to the Pump.

PULSOMETER STEAM PUMP CO.
Catalogue on Application.
Correspondence Solicited.
135 Greenwich Street, New York.

The Best **MINING PUMPS** In the World.

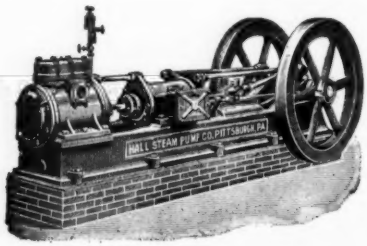
Send for Catalogues and Estimates.

OUR SPECIALTY.



11x16 in. and 26 in. x 7. x 24 in. Triple Expansion.

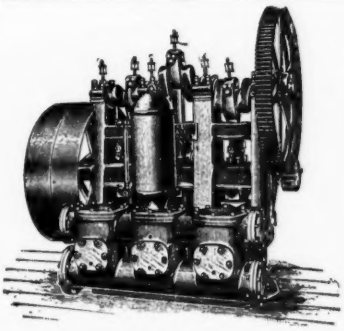
JEANESVILLE IRON WORKS CO.,
(INCORPORATED)
JEANESVILLE, PA.
WESTERN OFFICE:
1116 17th Street, Denver, Colo.



Air Compressors for Air Lift Well Pumping.
Air Compressors for Rock Drills, Coal Cutters, Air Hoists and Pneumatic work generally.
Pressure Pumps for Cotton Oil Mills and Cotton Compresses.
Steam Pumps, Single and Duplex, of all sizes and for all purposes.

Duplex and Triplex Power Pumps.

Hall Steam Pump Company,
CORRESPONDENCE SOLICITED. Pittsburg, Pa.



TRIPLEX POWER PUMPS,

Horizontal and Vertical.

AIR COMPRESSORS,

Single and Duplex Condensers,

Smith-Vaile Steam Pumps.

THE STILWELL-BIERCE & SMITH-VAILE CO.,

DAYTON, OHIO.

THE LAIDLAW-DUNN-GORDON CO.

General Offices, Southeast Corner Pearl and Plum Sts., Cincinnati, Ohio.

Factories, Tweedvale, Hamilton Co., Ohio, U.S.A.

—BUILDERS OF—

AIR COMPRESSORS.

STEAM PUMPING MACHINERY

FOR ANY SERVICE.

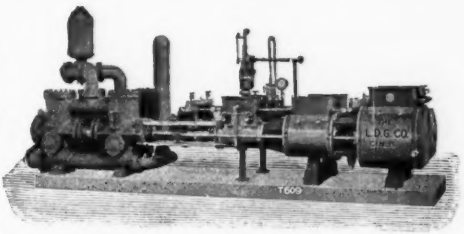
Boiler Feed Pumps. Electric Pumps.

Elevator Pumps. Water Works and Sewerage Machinery.

CORRESPONDENCE SOLICITED.

BRANCH OFFICES:

New York, 116 Liberty St. Philadelphia 333 The Bourse.
Pittsburgh Carnegie Building, Room 210.
Chicago 708 Fisher Bldg. Detroit 1129 Majestic Bldg.
Cleveland, 30 S. Water St. St. Louis, 811 N. Second St.

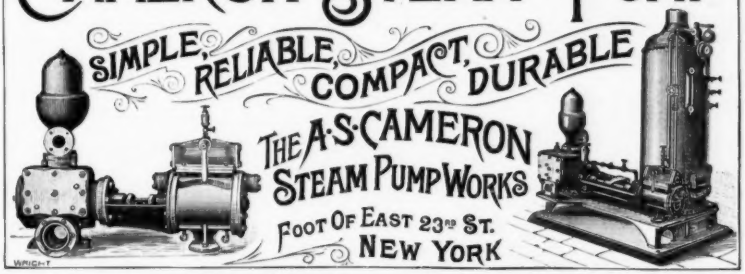


CAMERON STEAM PUMP

SIMPLE, RELIABLE, COMPACT, DURABLE

THE A·S·CAMERON STEAM PUMP WORKS

FOOT OF EAST 23RD ST. NEW YORK



The SNOW STEAM PUMP WORKS,

BUFFALO, N. Y., U. S. A.

MANUFACTURERS OF

ALL STYLES OF PUMPING MACHINERY

WRITE FOR CATALOGUE. IT WILL INTEREST YOU.

DRAWINGS, ESTIMATES, ETC., FURNISHED ON APPLICATION.

NEW YORK, PITTSBURG, SAN FRANCISCO,
BOSTON, PHILADELPHIA, LOS ANGELES,
CHICAGO, BALTIMORE, SEATTLE.

Please mention The Engineering Magazine when you write.

NIAGARA WATER METERS.

MANUFACTURED BY

BUFFALO METER CO.,

363 Washington St., - Buffalo, N. Y., U. S. A.

WESTINGHOUSE

ROTARY OR DISC

WATER METERS.

PITTSBURG METER CO., East Pittsburg, Pa., U. S. A.

THE JOHN H. McGOWAN COMPANY CINCINNATI, OHIO.

BRANCH, RICHMOND, VA.

PUMPING MACHINERY

FOR EVERY SERVICE

SINGLE DUPLEX AND CRANK AND FLY WHEEL TYPES.

WATER PIPE

Railroads, Mines, Distilleries and Pulp Mills.

SHIPPED WHOLE OR IN SPLIT SECTIONS

WOODEN CASINGS FOR STEAM PIPES.

FROM 2 TO 12 INCHES INSIDE DIAMETER

STEAM PIPE CASING

For Underground Steam Lines. The CHEAPEST and BEST Non-Conductor Made.

CREOSOTED CONDUIT

For Underground Wires of all Kinds. Cheap. Durable. Perfect.

These products are extensively used in Municipal and Railroad work. We can furnish reports showing Economy and Adaptability in all kinds of Service.

THE MICHIGAN PIPE CO., BAY CITY, MICH.

The ROESSLER & HASSLACHER CHEMICAL CO.

100 William Street, New York.

THE ROESSLER & HASSLACHER CHEMICAL COMPANY. CHEMISTS NEW YORK

Trade Mark.

CYANIDE

PEROXIDE OF SODIUM

HYPOSULPHITE OF SODA

CHLORIDE OF LIME

SULPHIDE OF IRON

And Other Chemicals for Mining Purposes.

THE JOHN F. BYERS MACH. CO.

RAVENNA, OHIO.

MFG'RS. OF GEARED LOCOMOTIVES, HOISTING ENGINES, TRAVELING DERRICK CARS, BUILDERS ELEVATORS

DERRICK IRONS, HAND POWERS. BLOCKS, SHEAVES, & CONTRACTORS SUPPLIES.

THE

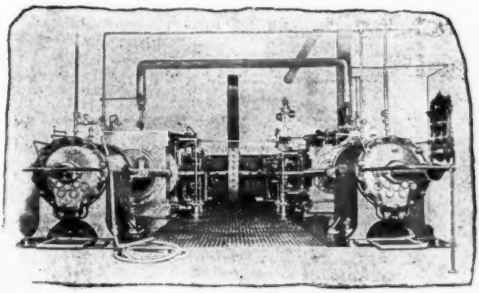
"Salem" Elevator Bucket

is made of any size required and of any strength of Steel for any purpose.

Send for current price list -free.

The W. J. CLARK CO., Salem, Ohio, U. S. A.

Please mention The Engineering Magazine when you write.



CUT THIS OUT
and send to us with name and address and get booklet
137
Shows 12 Types of

Air Compressors

Your Name and Address here:

.....

.....

.....

THE Ingersoll-Sergeant Drill Co.,

Havemeyer Building, New York.

Air Compressors, Rock Drills, Channelers, The Pohlé Air Lift Pump.

WE HAVE SOLD WITHIN 90 DAYS

SIXTY GRIFFIN MILLS

to the largest Cement Manufacturers, among them being the

AMERICAN CEMENT CO.	VULCANITE PORTLAND CEMENT CO.
ALPHA PORTLAND CEMENT CO.	PEERLESS PORTLAND CEMENT CO.
LEHIGH PORTLAND CEMENT CO.	GLENS FALLS PORTLAND CEMENT CO.
BONNEVILLE CEMENT CO.	CASTALIA PORTLAND CEMENT CO.

because they believed that The Griffin Mill beyond doubt does the best possible work at the smallest possible expense.

We will gladly send you full information, and very many American and Foreign references regarding it if you desire them.

BRADLEY PULVERIZER CO.,

92 State St., Boston, Mass., U. S. A.

Please mention The Engineering Magazine when you write.

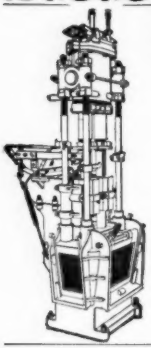
Our "Little Giant" Drill

in its present improved form, is away the best rock drill on the market. It is simple and therefore will last; is light in weight, yet strong, with a wide range of adjustability. Takes less power to drive it than other drills and will put down a hole in the shortest possible time. Get the whole story in our catalogue. Free.

RAND IMPROVED AIR COMPRESSORS.

RAND DRILL CO.

100 BROADWAY, NEW YORK.



STEAM STAMP MILL

No greater success in the 19th Century has been reached in machinery for milling ores. . . .

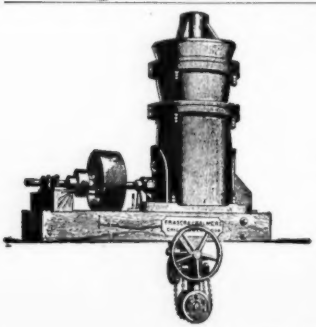
10 YEARS EXPERIENCE BEHIND THIS MILL.

Combines great capacity, light weight, small cost. Enables prospectors to develop their claims. Enables big companies to pay dividends.

GATES CRUSHING ROLLS, GATES NEW VANNERS, AND GATES ROCK & ORE BREAKERS.

If you want any kind of high grade **MINING MACHINERY** ask for our Catalogue, and address . . .

Gates Iron Works, DEPT. 9. 650 ELSTON AVE., CHICAGO.



Fraser & Chalmers.

157 FULTON STREET,

Chicago, Illinois,

announce to their patrons that the long-pending litigation with Gates Iron Works on

GYRATORY ROCK CRUSHERS

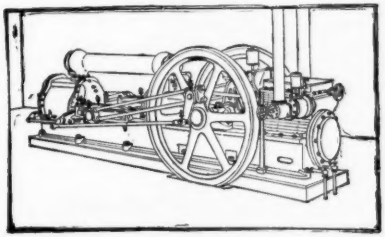
has been conclusively decided in favor of FRASER & CHALMERS. An account of the litigation, with catalogue of the

COMET ADJUSTABLE,

the best breaker on earth, will be mailed on request.

Please mention The Engineering Magazine when you write.

COMPOUND AIR COMPRESSORS



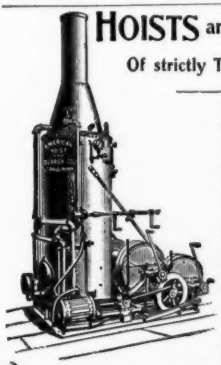
for driving coal cutters, drills, pneumatic tools, locomotives, and for all appropriate purposes. Any pressure. Any volume.

The Norwalk Iron Works Co.,

SOUTH NORWALK, CONN.

HOISTS and DERRICKS

Of strictly THE BEST Design.



STEAM, ELECTRIC, BELT, HORSE AND HAND POWER HOISTS.

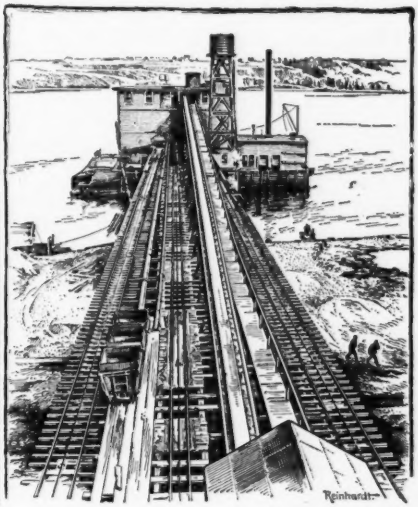
STEEL OR TIMBER, GUY, STIFF-LEG, TUBULAR, CRANE AND TRAVELLING DERRICKS.

AMERICAN HOIST & DERRICK CO.,

ST. PAUL, MINNESOTA.

Chicago: 60 S. Canal St. *New York:* Havemeyer Bldg. *New Orleans:* Hennen Bldg.

ROBINS BELT CONVEYORS.

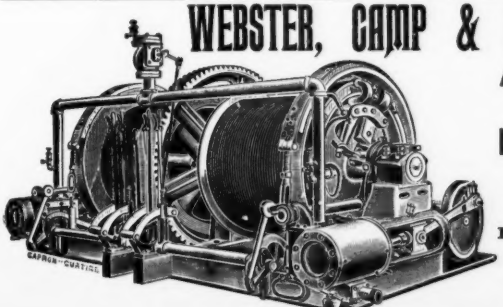


The above cut shows one of our Patent Belt Conveyors which is used for loading scows with sand, gravel and stone up to 4″ in size. Three-car trains of automatic dump cars, running on the tracks shown above, were formerly used for this purpose. The belt conveyor is 400 ft. long between centres and has a capacity of over 400 cu. yds. per hour. The cars never exceeded 250 yds. per hour and required the attendance of six extra men. Estimates will be cheerfully furnished.

ROBINS CONVEYING BELT CO., 147-149 CEDAR STREET. NEW YORK, U. S. A.

THE ENGINEERING INDEX places the contents of any engineering paper in English, French or German before the engineer each month, and furnishes a means of getting quickly any particular article desired.

WEBSTER, CAMP & LANE MACHINE CO.,



AKRON, OHIO, U. S. A.

MANUFACTURERS OF

MINING MACHINERY,

HIGH-GRADE

HOISTING ENGINES

FOR EVERY KIND OF SERVICE

CABLE ADDRESS,

"WEBCAMPCO—AKRON"

A. B. C. 4TH ED & LIEBERS STD. CODES.

Please mention The Engineering Magazine when you write.

WIRE ROPE

FOR ALL PURPOSES.

IRON AND STEEL WIRE

OF ALL KINDS.

Wire Rope Tramways, Cable Hoist Conveyors,
Hall Patent Excavating Cable Hoist Conveyor, Surface and Underground Haulage Plants,
Wire Rope Power Transmission Plants,
Log-Skidding and Canal Towage Plants, Suspension Bridges.

TRENTON IRON CO., TRENTON, N. J.

NEW YORK OFFICE—Cooper, Hewitt & Co., 17 Burling Slip. CHICAGO OFFICE—1114 Monadnock Building.

THE ENGINEERING INDEX places the contents of any Engineering paper in English, French, or German before the Engineer each month, and furnishes a means of getting quickly any particular article desired. . . . . .

7649

The Odorless Excavating Co.,

MANUFACTURERS OF THE MOST IMPROVED

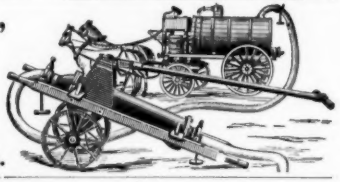
Pumps and Apparatus for Cleaning Vaults and Cesspools.

Cities, Towns and Corporations Furnished with Complete Outfit for Odorless Excavation.

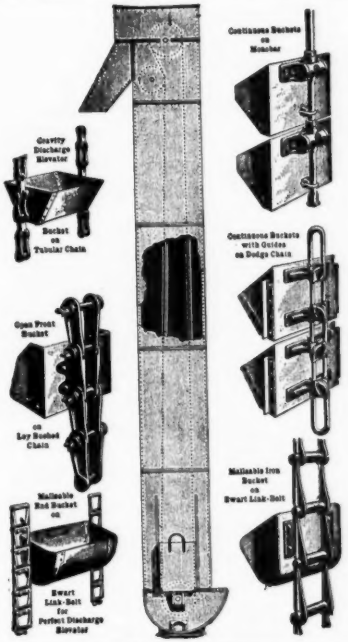
SEND FOR CATALOGUE AND PRICE-LIST.

ESTABLISHED 1859. INCORPORATED 1883.

BOSTON, MASS.



JOHN A. ROEBLING'S SONS CO.
IRON & STEEL
WIRE ROPE
TELEGRAPH WIRE COPPER WIRE
Works at Trenton, N.J.
WAREHOUSES.
117 LIBERTY ST., NEW YORK.
25 FREMONT ST., SAN FRANCISCO.
173 LAKE ST., CHICAGO, ILL.
INSULATED MAGNET WIRE & ELECTRIC WIRES.


Gravity Discharge Elevator
Bucket on Tubular Chain
Open Front Bucket on Leg Bucket Chain
Malleable End Bucket on Swart Link-Belt for Perfect Discharge Elevator
Continuous Buckets on Monobar
Continuous Buckets with Guides on Dodge Chain
Malleable Iron Bucket on Swart Link-Belt

LINK = BELT

Elevators, Conveyors, Power Transmissions, Iron and Steel Structural Work.

Descriptive Catalogue on Application.

Link=Belt Engineering Co.,

NICETOWN, PHILA.,
49 DEY STREET, NEW YORK.

I am much pleased with THE ENGINEERING MAGAZINE. I consider it one of the most valuable publications for general information on engineering topics.
G. WILBUR HURLEY, Sup.,
Louisville Electric Light Co.,
Louisville, Ky.

Hoisting Machines.

Steam, Horse, and Hand Power.

Derrick Iron and Contractors' Supplies.

A very complete and useful catalogue sent free. Mention this magazine.

Contractors' Plant Mfg. Co.
(LIMITED.)
129 Erie Street, Buffalo, N. Y.

JEFFREY

Roller, Steel and Special Chains
—FOR—
ELEVATING AND CONVEYING MACHINERY

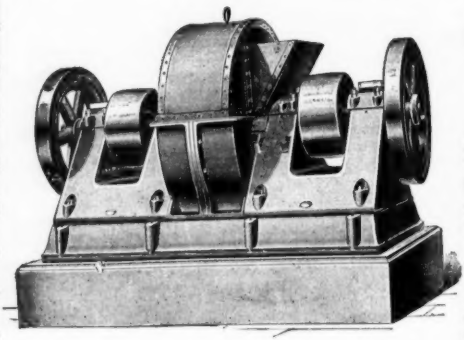
COAL MINING MACHINERY.

Wire Cable Conveyors.
For long and short distance conveying.

THE JEFFREY MFG. CO.
Columbus, Ohio.

41 DEY STREET, NEW YORK.
Send for Catalogue.

STEDMAN'S Foundry and Machine Works, **Aurora, Ind.**



MANUFACTURERS OF IMPROVED

Disintegrators and Pulverizers

for Reducing

Clays, Iron, Coal, etc.,

for various purposes.

Graphite Crucibles and Slag for use in Rolling Mills, Guano, Phosphate, Bones, Etc., for Fertilizer.

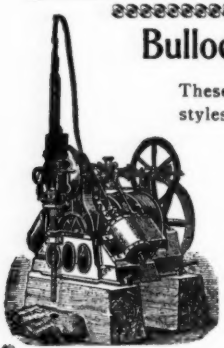
We have positively the best and most satisfactory mill on the market.

This machine is a perfect success for breaking up or pulverizing GOLD and SILVER SLIMES.

Write for Illustrated Catalogue and Prices.

Our Mills for Crushing Coal to Make a Superior Quality of Coke are Indorsed by all the Leading Coal and Coke Compnies.

In 1897 THE ENGINEERING INDEX contained 7649 separate references to leading articles in leading engineering publications.



DELVER DRILL.
2¼" Hole, 2" Core,
2000 feet deep.

Bullock's Diamond Prospecting Core Drills.

These Machines will give absolutely accurate records of borings. Fifteen styles and sizes. Operated by hand, horse, steam, air or electricity.

We make a specialty of prospecting by contract for GOLD, SILVER, IRON, COPPER, LEAD, TIN, ZINC, COAL, SALT, ETC.

Monarch Rock Drills and Air Compressors

Full specifications furnished on complete rock drilling plants.

Hoisting and Haulage Machinery

to fill any requirements.

Central = Valve = Engines,

ECONOMICAL—DURABLE—EFFICIENT.

Especially Adapted for DIRECT COUPLING and all other HIGH SPEED INSTALLATIONS.

M. C. BULLOCK MFG. CO.,

1173 W. Lake Street, **CHICAGO, U. S. A.**

Please mention The Engineering Magazine when you write.

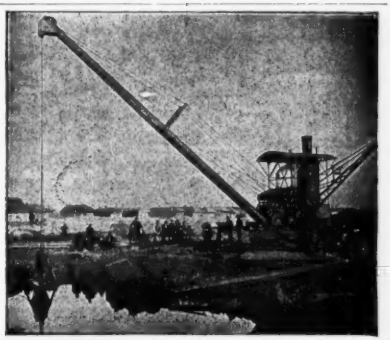
THE BROWN HOISTING AND CONVEYING MACHINE CO.,

CLEVELAND, OHIO.

Machinery for handling COAL and ORE.

Machinery for handling material in SHIPBUILDING YARDS, Plates, Structural Work, Etc.

CRANES of all TYPES, Electric, Steam and Hand Power.



THE SULLIVAN DIAMOND PROSPECTING DRILL

The **DIAMOND DRILL** is invaluable for the preliminary testing or later development of mineral property. It bores to **any depth** at **any angle**, and removes a **solid core** or section showing the **location, thickness** and **quality** of the **mineral.**

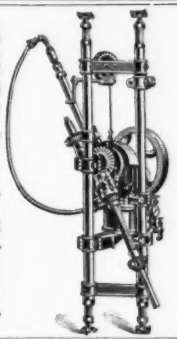
THE QUICKEST, CHEAPEST & BEST METHOD OF PROSPECTING. THE MOST ACCURATE & RELIABLE RESULTS.

Diamond Drills operated by Hand or Horse Power, Steam, Compressed Air or ELECTRICITY.

GENERAL QUARRYING MACHINERY—Channeling and Gadding Machines.

COAL MINING MACHINERY.

Contractors for Prospecting Mineral Land with the Diamond Core Drill.



"E" Drill for Prospecting Underground.

SULLIVAN MACHINERY CO.,

54-60 N. Clinton St., CHICAGO, ILL. 339 Fifth Ave., PITTSBURG, PA. 412 17th St., DENVER.

A Specimen Card

(HALF SIZE.)

Steam Power.

The Cost of Steam Power. Horatio A. Foster. Abstract of paper read before the Am. Inst. of Elec. Engs. Showing that any general statement of the cost of power per horse power per annum is incorrect, and that no such statement is of any value unless for plants employed in similar work under similar conditions. Gives tabulated data of plants tested. 4000 w. St. Ry. Jour.—Aug., 1897. No. 14460 D.

The ENGINEERING INDEX published in this Magazine each month is an index to the current contents of some 200 of the leading engineering and technical journals and transactions of important societies published anywhere in the world in English, French, and German.

This Index gives the title of each important article, its author, an abstract of its contents and purpose, its length, and date of publication.

To keep a list of articles, possibly useful for future reference, it is only necessary to cut out the corresponding index notes and file them in any convenient manner, preferably on cards, which admit of alphabetical arrangement, or classification in any desirable manner.

See page 1041 for Introductory Description.

TEST YOUR LAND FOR GAS OR OIL.

There may be a fortune under your feet.

The Portable STAR DRILLING MACHINE

is suitable for Oil, Gas, Water and Mineral Prospect Wells.

Every machine is complete in all its details, with patent spudding attachment which requires no changes to operate it; sand pump, smithing tools, drill and sand pump ropes, etc.

ABSOLUTELY WITHOUT SPRINGS.

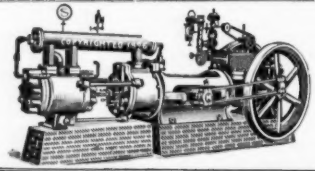
These machines are the best in the world for drilling purposes, as **they are complete in every particular.** They are made in ten different sizes to **drill 250 to 2500 feet in depth.**

Cable Address: "STARDRILL." Use "A-B-C Code, 4th Edition," or "Universal Code of Lieber."

Send for our Illustrated Catalogue.

STAR DRILLING MACHINE CO.
AKRON, OHIO U. S. A.

THE AMERICAN WELL WORKS "LIGHTNING WELL MACHINERY"



MANUFACTURERS OF

AIR LIFTS,
AIR COMPRESSORS,
DEEP WELL PUMPS,
GASOLINE ENGINES,
WELL MACHINERY.

CHICAGO ILL. DALLAS TEX. AURORA ILL. WRITE FOR CATALOGUE 200

WELL DRILLING MACHINERY.

MANUFACTURED BY

WILLIAMS BROTHERS.

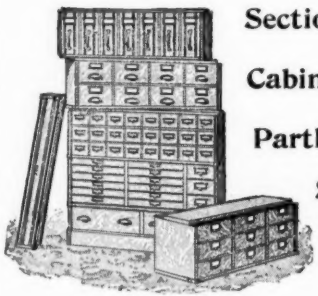
ITHACA, N.Y.

MOUNTED OR ON SILLS, FOR DEEP OR SHALLOW WELLS, WITH STEAM OR HORSE POWER

SEND FOR CATALOGUE

ADDRESS WILLIAMS BROS. ITHACA, N.Y.

Globe-Wernicke



Sectional Cabinet Partly Set Up.

We have filing cabinets suited to your present needs. We have filing cabinets suited to your needs ten years from now. You say the one is too small and the other too large. But we have a cabinet that grows as business grows—THE GLOBE-WERNICKE CABINET—one size this year, twice as big next year if you want it, but always the same cabinet.

Catalogue showing details of construction and different interiors by mail FREE.

The GLOBE COMPANY, Cincinnati, O.

Cor. Fulton & Pearl Sts., N. Y.
226-228 Wabash Ave., CHICAGO.

Military Engineering

is a new department in The Engineering Index of timely interest.

See page 1041 of this Magazine.

BALDWIN LOCOMOTIVE WORKS,

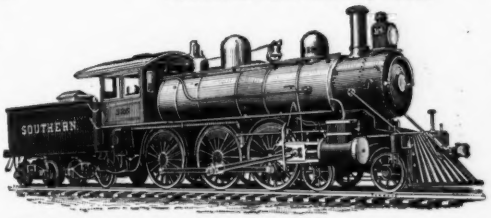
ESTABLISHED 1831. ANNUAL CAPACITY, 1000.

Locomotive Engines

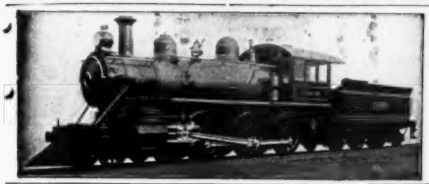
adapted to every variety of service, and built accurately to standard gauges and templates.

Locomotives for Logging, Railroads & Sugar Estates, Electric Locomotives, Compressed Air Locomotives.

Compound Locomotives, Steam Cars, Steam Tramway Motors, Mine Locomotives, Furnace Locomotives.



BURNHAM, WILLIAMS & CO., Proprietors,
500 N. BROAD ST., PHILADELPHIA, PA.



Pittsburgh Locomotive Works,

PITTSBURGH, PA.

Builders of Simple and Double Expansion Locomotives for every class of service.

Tanks, Locomotive or Stationary Boilers.

THE

Westinghouse Air-Brake Co.,

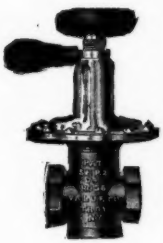
MANUFACTURERS OF

AIR-BRAKES

—FOR—

LOCOMOTIVES AND CARS.

PITTSBURGH, PA.

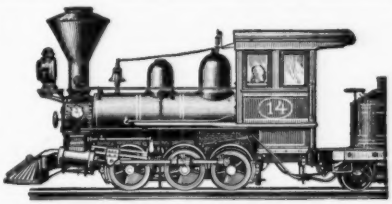


ROSS VALVE CO.,

TROY, N.Y.

ROSS REGULATOR VALVES, for steam and water. Will control the flow and maintain any desired pressure. For car heating it has no equal. No complicated parts. It is easily understood. It is durable, low in price, and always reliable. Made in sizes from 1 to 12 inches.

THE ENGINEERING INDEX places the contents of any Engineering paper in English, French or German before the engineer each month, and furnishes a means of getting quickly any particular article desired.



H. K. Porter & Co.,

BANK OF COMMERCE BUILDING,

PITTSBURGH, PA.

On bona-fide application of intending purchaser or user of locomotives we will mail free, our new 216 page pamphlet, describing 394 **Light Locomotives,** steam, electric and pneumatic, with tables, formulas, etc. To persons not requiring locomotives we will send catalogue on receipt of 50 cts. in stamps.

Locomotives wide and narrow gauge always on hand.

Please mention The Engineering Magazine when you write.

Please mention The Engineering Magazine when you write.

THE NEW YORK AIR BRAKE CO.,

C. A. STARBUCK, President.
J. C. THOMPSON, Sec.-Treas.

66 Broadway, NEW YORK.

European Address: Fred. Stieltjes & Co., Keizersgracht 745, Amsterdam, Holland.

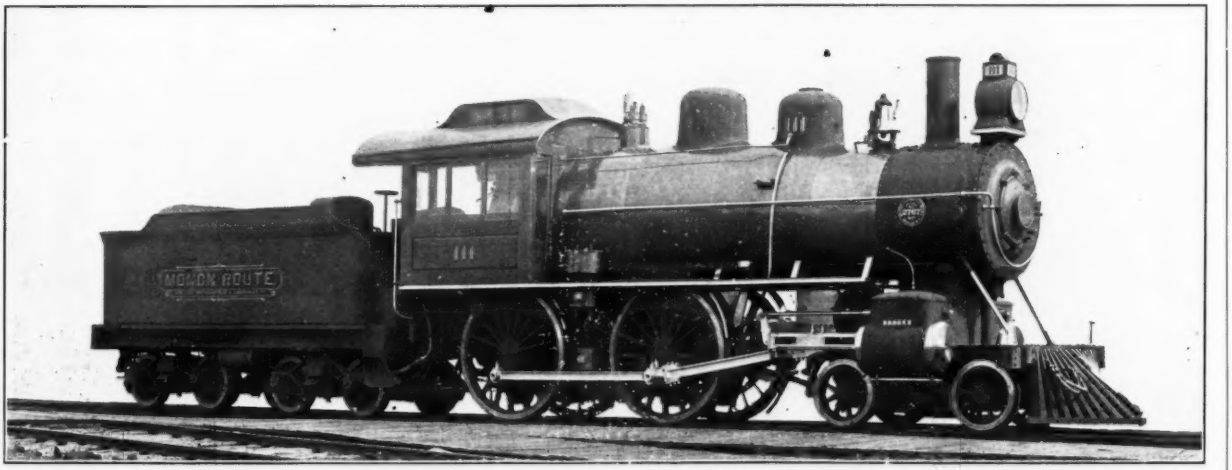
THE THOUSANDS OF **NEW YORK AIR BRAKES** ALREADY IN USE ON FREIGHT CARS, ON PASSENGER CARS, ON MODERN HIGH SPEED LOCOMOTIVES AND UP-TO-DATE LOCOMOTIVES FOR FREIGHT TRAINS, ALL TELL THEIR OWN STORY. THEY

INTERCHANGE PERFECTLY,

AND ARE SATISFACTORY IN EVERY WAY. THIS BRAKE IS THE RESULT OF **LONG EXPERIENCE** AND IS MADE OF THE **BEST MATERIALS.** IT IS USED BY SOME OF THE FOREMOST RAILWAYS IN THE WORLD, AND WHERE IT GETS THE HARDEST KIND OF SERVICE. BELOW IS A NOTABLE EXAMPLE

SHOWING THE

NEW YORK AIR BRAKE

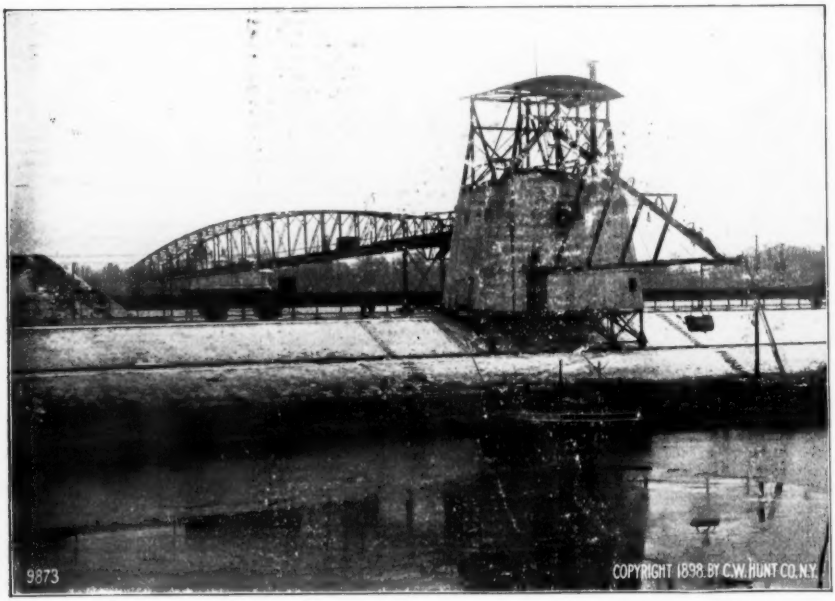


ON A HIGH SPEED ENGINE.

The Engine—and
THE BRAKE
Speak for Themselves.

Please mention The Engineering Magazine when you write.

THE HUNT SYSTEM
OF COAL HANDLING MACHINERY.



Hunt Elevator and Automatic Railway erected for the Rheinisch-Westfaelisches Kohlen-Syndicat at Ludwigshafen, Germany. The automatic railway is carried on a bridge, 100 metres (328 feet) span. The whole plant, bridge, automatic railway and hoisting tower, moves together for about 1000 feet on the wharf.

This is another of the many great plants we have installed, and our catalogues illustrate and describe.

Our line is primarily machinery for handling heavy or bulky materials. We build Automatic, Cable, and "Industrial" Railways;—Hoisting Engines, Steam Shovels, Coal Tubs,—Hunt Noiseless Conveyor, Coal Crackers, Coal Chutes, Coal Valves, etc. We make a special Manila rope sold under the trade name of "Stevedore" which we guarantee to be the best rope on the market for hoisting and transmission without any exception whatever.

We have been in this special line of business since 1872 (26 years), and our coal handling machinery is in use in almost every port of America, and in almost every country in the world. We have ample shops and capital, and manufacture everything we sell, thus we have control over both the quality of material and workmanship that otherwise we could not have. We design and make plans for all classes of wharves, trestles, and storage buildings for storing coal and ore, and similar materials.

Write us your requirements. Our catalogues are free to interested parties. Address the works direct.

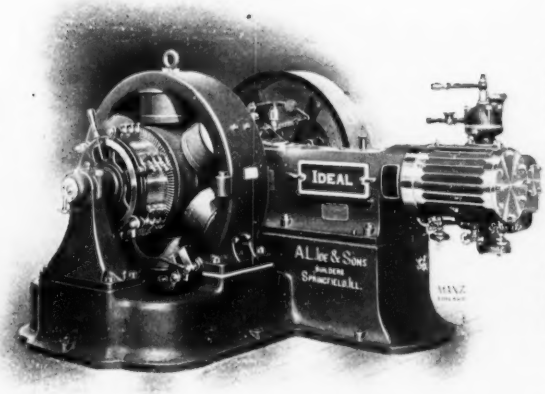
C. W. HUNT COMPANY, CEDAR ST.,

WEST NEW BRIGHTON, - STATEN ISLAND, N. Y.

Please mention The Engineering Magazine when you write.

Ideal Self-Oiling Automatic Engine.

SIMPLE AND TANDEM COMPOUND.



Direct Connected to Electric Generators,

12 to 500 Horse Power.

Agencies.

D. Adamson & Co., Dukinfield, near Manchester, England. For Great Britain and Dependencies. Cable Address, "Adamson, Dukinfield."

F. W. Horne, Yokohama, Japan. For China and Japan. Cable Address, "Horne, Yokohama."

Compañia Industrial Mexicana, Chihuahua, Mexico.

Machinery & Electrical Company, Los Angeles, Calif.

Abner Doble Company, San Francisco, Calif.

J. M. Arthur & Co., Portland, Oregon.

English Supply & Engine Company, Kansas City, Mo.

J. G. Robertson, Manhattan Building, St. Paul, Minn.

M. T. Morrill, Golden, Colo.

E. T. Barden, Houston, Texas.

Licensed Manufacturers.

Harrisburg Foundry & Machine Works, Harrisburg, Pa. For New England and Southern States.

Goldie & McCulloch Co., Galt, Ontario, Canada. For Canada.

A. L. IDE & SONS, BUILDERS, SPRINGFIELD, ILL., U. S. A.

G. G. TURRI & CO.,

Patent Agents and Company Promoters,

For all business appertaining to the above professions in the colonies of VICTORIA, N. S. WALES, S. AUSTRALIA, WEST AUSTRALIA, QUEENSLAND, NEW ZEALAND, TASMANIA and FIJI.

Established 1887. Actually employed by over 50 leading American and European Patent Attorneys and Agents. The only Patent Agents employed by the Victorian Government (Mines Department) for whom Mr. Turri in 1896 won the famous *Cyanide* Coal (MacArthur-Forrest Patent).

SUN BUILDING,

Cor. QUEEN & BOURKE STS., - MELBOURNE, AUSTRALIA.

Memo. of Terms to Patent Agents. Patent applications for Victoria, if all documents sent in order for acceptance carried through for £3 12s. all government fees included. Trade Mark applications £1 16s. Forms, Acts, and Rules for any colony sent free on application. Inventors and Trade Mark owners should do business with us through some Patent Agent, Attorney, or Solicitor in their own country as direct correspondence is not our practice. We are open to entertain proposals to float companies or to patent inventions at our own cost in return for a share of same if advised fully immediately patent application is lodged in America or England. No attention will be paid to inventions not shown clearly to possess large commercial value in Australia.

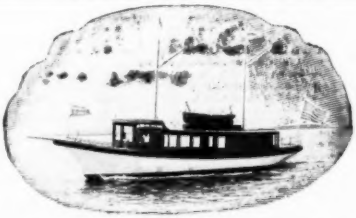
GEORGE G. TURRI,

Certificated to Practice by Attorney-General, Victoria. Commissioner of Patents, Washington, D. C., and the Commissioner of Patents, Melbourne.
F. Member Institute Patent Agents, Paris.
Member of Council Aust. Inst. Mining Engineers.
Member Victorian Institute of Engineers.
Fel. Soc. Chemical Industry, London.
Memb. of Council, Vic. Chamber of Manufactures &c., &c.
Commissioner for Declarations and Affidavits.

Paddle Wheel Machinery

Our knowledge of river navigation is earned through long experience and exceptional opportunity. We design and build the *entire and complete* outfits of driving machinery for powerful light draft vessels, having the best of modern shop facilities to aid us in doing *all* the work. Write to us before you act.

MARINE IRON WORKS
Station A. CHICAGO.



Highest Grade Launches
are those equipped with
Daimler Motors

which are recognized as the safest, simplest, most economical and always reliable Power for Marine and portable purposes.

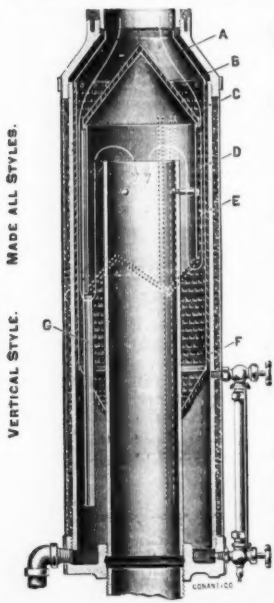
We manufacture these motors in sizes from 1 to 25 H. P., and we build Pleasure Boats in all sizes and styles from a 16 ft. Tender to a 100 ft. Yacht.

The largest Motor Power Yachts now afloat are built by us and are equipped with our Motor.

For Catalogue please write to

DAIMLER MOTOR WORKS,
937-945 STEINWAY AVENUE,
STEINWAY, LONG ISLAND CITY, N. Y.

SWEET'S DIRECT SEPARATOR



—FOR—
Dry Steam.

IT HAS A
Large Separating Surface, A Big Receiver Capacity Traps Every Drop and is A Finished Machine.

Tested at Cornell University, Pittsburg Water Works, and in use in hundreds of Steam Plants.

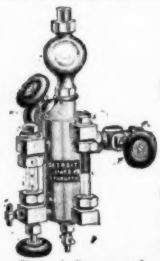
Special Design for Oil. Send for Reports of Tests.

Direct Separator Co.,
518-30 Geddes St.
Syracuse,
N. Y., U. S. A.

¿7649?

MORE THAN 350,000 DETROIT LUBRICATORS

Are in use on the World's Engines.



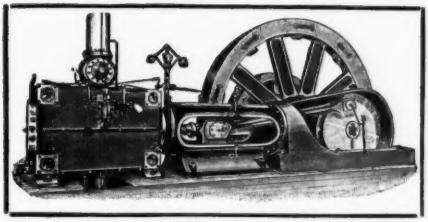
Detroit Improved Standard Lubricator.

Standard in all Countries—
Equalled in None.

Our new Catalogue explaining our Different Styles for every kind of Engine, sent on application.

Detroit Lubricator Co.,
Detroit, Mich., U. S. A.

HAMILTON-CORLISS.



Correspondence Solicited. Call for Catalogue E.

Highest Efficiency and Superior Construction.

Non-Condensing, Condensing, Compound, Triple-Expansion or Quadruple Expansion.

Close Regulation and Best Attainable Economy of Fuel and Steam.

THE HOOVEN, OWENS & RENTSCHLER CO.,
HAMILTON, OHIO, U. S. A.

All we ask is your address

and we will send you free one
of our new catalogues of our
Automatic Cut-off Engines.
Rites Governing System used.

CHANDLER & TAYLOR CO.,
Indianapolis, Indiana, U. S. A.

We also manufacture high class Throttling Engines and Steam Boilers.

FRICK COMPANY, Waynesboro, Pa.

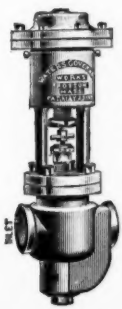
ECLIPSE CORLISS ENGINES.

ELECTRIC HIGH-SPEED ENGINES.

ICE-MAKING AND REFRIGERATING MACHINERY.

40 to 2,000 H. P. All Styles. Send for Illustrated Catalogue.

NEW YORK OFFICE, Taylor Building, 39-41 Cortlandt Street.



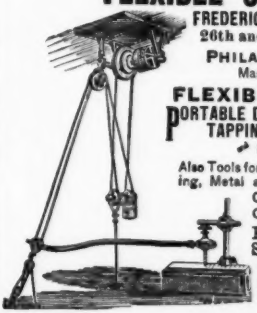
WATERS GOVERNOR COMPANY.

REDUCING VALVES,
PRESSURE REGULATORS,
BALANCED VALVES, Etc.

Simplicity and accessibility are the chief points of excellence in our specialties. If you are not familiar with them, write for our descriptive circulars.

34 OLIVER STREET,
Boston, Mass., U. S. A.

FLEXIBLE SHAFT CO.,



FREDERIC SCHOFF, PROP.
26th and Callowhill Sts.,
PHILADELPHIA, PA.
Manufacturers of

FLEXIBLE SHAFTS,
PORTABLE DRILLING, TAPPING, REAMING & BORING MACHINES

Also Tools for Emery Wheel Grinding, Metal and Wood Polishing, Cattle Brushing and Clipping.

Builders of Special Machines for Railroads, Bridge and Boiler Makers, Contractors, &c.

Please mention The Engineering Magazine when you write.

STEARNS MANUFACTURING CO.

ERIE, PENN.

As between no load and full load an instantaneous change of speed of less than one per cent. is guaranteed. We build Governors for other Engines that are not regulating satisfactorily.

Write for particulars of the Woodbury Automatic High Speed Engine with the new Shepherd Governor. Address **ERIE, PENN.**, or

BURHORN & GRANGER, 136 Liberty St., New York.
A. H. RIDDELL, 81 Forest Bldg., Phila.
KELLOGG & WITHERBEE, 41 Federal St., Boston.
W. J. CREELMAN, 818 Granite Bldg., Rochester, N.Y.
GEO. CAYWOOD, 1120 The Rookery, Chicago.
THE W. T. SPRAGUE CO., Lumber Exchange, Minneapolis, Minn.
JOHN D. EBY, 29 & 31 Spear St., San Francisco, Cal.

FUEL GAS PLANTS FOR FACTORIES.

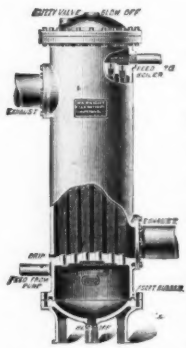
COMPLETE INSTALLATION, INCLUDING

GAS BLAST FURNACES FOR ANY KIND OF WORK.

THOROUGH EFFICIENCY, ECONOMY AND SAFETY WARRANTED.

Descriptive Pamphlets on application to

AMERICAN GAS FURNACE CO., - - 23 John Street, New York.

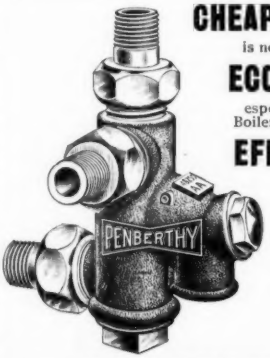


A change in owners, a change in minds, a change in plans, and, as a consequence, we have on our hands a brand new Wainwright water tube heater with 650 square feet of heating surface which we offer for sale at a very low price. Send for blue print 2B–77, and find out just what this is.

* * *

Taunton Locomotive Mfg. Co.,

Taunton, Mass., U. S. A.



CHEAPNESS
is not always
ECONOMY
especially in Boiler Feeders.
EFFICIENCY
of
$99\frac{22}{100}$ %
to
$99\frac{1}{2}$ %
is shown by
TWO TESTS
of the

WORLD RENOWNED

TRADE **PENBERTHY** MARK.

AUTOMATIC INJECTOR

by experts in no way connected with our factory.

PENBERTHY INJECTOR CO.,

115-121 Seventh Street, Detroit, Mich.

LARGEST INJECTOR MANUFACTURERS IN THE WORLD.

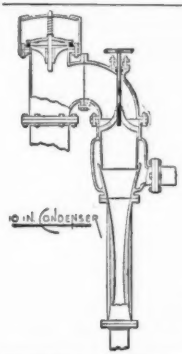
Please mention The Engineering Magazine when you write.

BUNDY STEAM TRAP.
A. A. GRIFFING IRON CO.
66-68 CENTRE ST., NEW YORK.
Boston. Philadelphia.
WORKS: JERSEY CITY.
Send for book -EN-
"*Fuel Economy.*"

Bundy TRADE MARK

RETURN STEAM TRAPS.
TANK STEAM TRAPS.
STEAM SEPARATORS.
OIL SEPARATORS.
GRAVITY PUMPS (Traps).
FEED WATER HEATERS.
EXHAUST PIPE HEADS.
SAFETY WATER COLUMNS.

SELLING AGENTS.
John G. O'Neil, 335 The Rookery, Chicago, Ill.
Geo. G. Semans, 209 Ninth St., Pittsburg, Pa.
E. M. Birdsall, 940 Ellicott Square, Buffalo, N.Y.



The Baragwanath Condenser

Requires No Air Pump. 24" to 26" Vacuum Guaranteed.
20% to 30% Saving in Fuel. **Low in Price.**

WM. BARAGWANATH & SON,
42 W. DIVISION STREET, CHICAGO, ILLS.
Manufacturers of FEEDWATER HEATERS, PURIFIERS, Etc., Etc.

THE BEST

is not always the cheapest, nor the cheapest the best; but the

CUMMER DRYERS

are both the cheapest and best. No matter what the material or materials to be dried, we'll furnish you a dryer guaranteed to do the biz.

Write for Catalogue.

The F. D. Cummer & Son Co.,
CLEVELAND, OHIO.

Hoppes

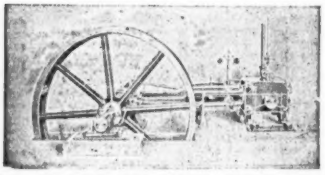
LIVE STEAM FEED-WATER
PURIFIERS

Guaranteed to keep Boilers Clean and free from Scale.

EASTERN OFFICE;
604 GIRARD B'LD'G.,
PHILADELPHIA.

New Catalogue FREE.

THE HOPPES MFG. CO.,
63 LARCH ST., SPRINGFIELD, OHIO.



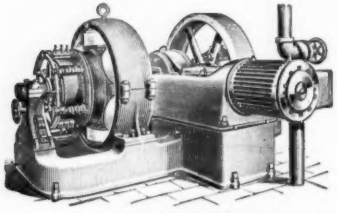
THE VILTER MFG. CO., 1002 Clinton Street, Milwaukee, Wis., U.S.A.

BUILDERS OF IMPROVED

CORLISS ENGINES.

Ice-Making and Refrigerating Machinery.

AMERICAN-BALL ENGINES AND GENERATORS.



Complete plants including motors of our own manufacture.

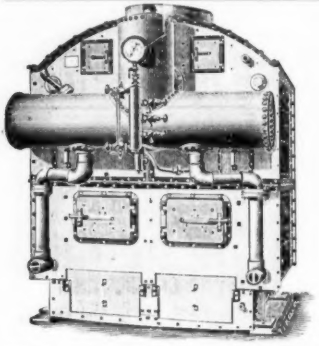
Our recent exhibit at the Madison Square Garden Exhibition comprising an engine, generator and motor, was the only exhibit of a complete plant of this type built by one concern. The large volume of business resulting from the exhibition is the best evidence of the appreciation of our machinery by the public.

AMERICAN ENGINE CO.,

20 RARITAN AVENUE, BOUND BROOK, N. J.

I find your Magazine of value as a technical paper, and very readable besides—to say nothing of other important characteristics.

W. E. SAUNDERS, E. M.,
Helena, Mont.

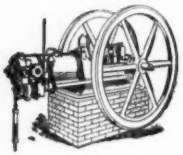


Almy Water-Tube Boiler Co.,

178-184 Allen's Ave., Providence, R. I.

The Almy Water-Tube Boiler is cased in metal, the advantage over brick-set boiler being that there is no leakage of cold air into the boiler to reduce temperature. Another advantage is small radiating surface. While the temperature of our jacket is no higher than that of a brick-set boiler, there is about ¼ the space to radiate from.

Ask for free catalogue: it interests boiler buyers.



OTTO GAS AND GASOLINE ENGINES.

1 to 250 Horse Power.

Over 45,000 Sold.

Can be used in cities or in country independent of gas works or gas machines.

No Boiler. No Danger. No Engineer.

THE OTTO GAS ENGINE WORKS, Inc.,

23d and Walnut Sts., PHILADELPHIA.

RIFE HYDRAULIC ENGINES

PUMP WATER BY WATER POWER.

Put in Place of Rams. Deliver More Water. Never Stop. Your Money Back if You Want It.

Send your conditions for catalogue and guaranteed estimate.

RIFE ENGINE CO., 126 Liberty Street, New York.

For the busy man

THE ENGINEERING INDEX saves the most time and money—the only way to keep well up to date in engineering progress.

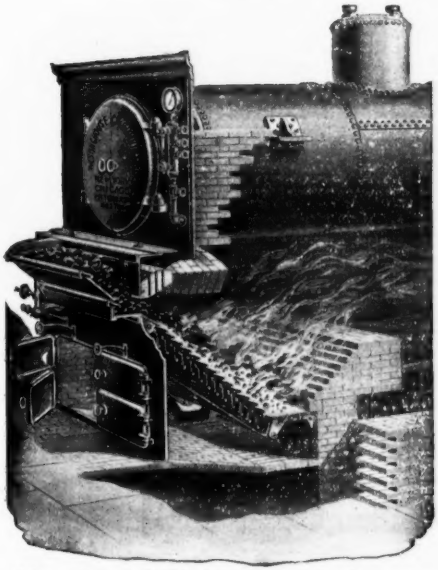
Please mention The Engineering Magazine when you write.

The Westinghouse Machine Company

MANUFACTURERS.

Westinghouse, Church, Kerr & Company

ENGINEERS.



If asked what we consider to be

The most valuable feature of The Roney Mechanical Stoker,

we might hesitate a moment, and insist on making a list of valuable features. But near the top of the list, we would put this point:

The entire bed of fire is visible from the under side of the grate.

Clinkers can be seen as they form and can be dislodged from the under side of the grate.

If the fire is burning unevenly or in holes, this state of affairs can be instantly detected and corrected.

Little or nothing can be seen in the interior of a white-hot furnace. The unequaled facilities which the ***Roney Mechanical Stoker*** affords for observing the condition of the fire, makes the burning of coal more a question of ***good judgment,*** and less a question of ***good guessing.***

- - - OFFICES. - - -

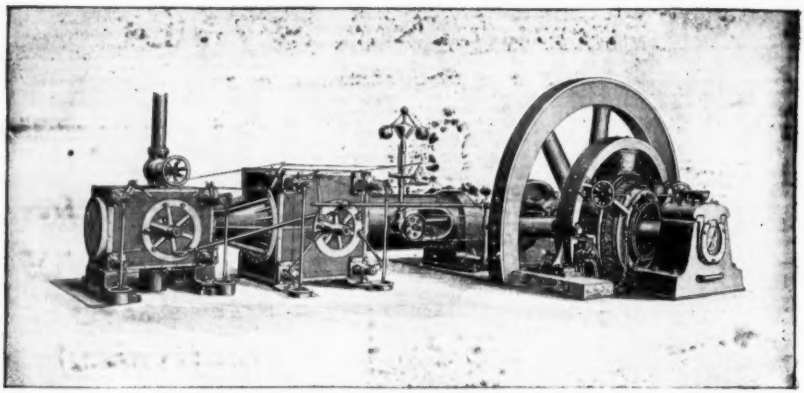
NEW YORK, 26 Cortlandt Street. BOSTON, 53 State Street.
CHICAGO, 1171 La Salle Street. PITTSBURG, Westinghouse Building.
DETROIT, Union Trust Building.
PHILADELPHIA, M. R. Muckle, Jr., & Co., Drexel Building.

Please mention The Engineering Magazine when you write.

THE EDWARD P. ALLIS COMPANY,

MILWAUKEE, WIS.

MANUFACTURERS OF REYNOLDS CORLISS ENGINES.



Blowing Engines, Hoisting Engines, Pumping Engines, Air Compressors, Special Engines for Electric Lighting, Street Railways and Rolling Mills, Ore Crushers, Crushing Rolls, Stamp Mills, Concentrators, General Mining, Milling and Smelting Machinery.

BRANCH OFFICES: { NEW YORK, CHICAGO, SAN FRANCISCO, BUTTE, MINNEAPOLIS, DENVER, PITTSBURGH, CITY OF MEXICO.

COCHRANE SEPARATORS

BLUE STEAM

Ever notice the color, or apparent color effect, of a jet of steam issuing from a pet cock in a live steam main? Was it whitish? That was due to entrained moisture. The bluish color or perfect transparency is present only when the steam is dry.

Dry steam (it does not matter how wet it was originally) can always be had using a COCHRANE STEAM SEPARATOR. The mission of these appliances is to take water out of steam—to insure dry steam to engines, whether the steam comes ladened with a small quantity of moisture, or whether it is carrying a "flush" or a "slug" of water.

And as for thoroughly purifying exhaust steam from cylinder oil—the COCHRANE OIL SEPARATORS will do it; at any rate, the 1200-odd Cochrane Oil Separators we have out are doing it to the satisfaction of their owners.

In our new Separator catalogue, which is fully illustrated, we detail something like 105 different sizes and constructions—building Separators to suit the conditions being one of our hobbies. Postal card requests for these catalogues will not be noticed.

COCHRANE SEPARATORS

HARRISON SAFETY BOILER WORKS,
(Columbia Station) Philad'a, Pa.

If you want "blue steam" dye it blue;
or try a COCHRANE SEPARATOR.

Please mention The Engineering Magazine when you write.

DEARBORN
VEGETABLE BOILER COMPOUNDS

Scientifically and Uniformly Made.

EVER RELIABLE.

Most Scientifically Equipped, Complete, Handsome and Expensively Furnished Laboratories, and the Only Exclusive Laboratories on Steam Economy in the Country.

NO man interested in steam should miss calling at the **Dearborn Laboratories** when in **Chicago.** An engineer should be honest to his boilers and not cover up the fact that they are scaly, when he can stand out like a man and ask for a proper compound and have clean boilers, and thereby save all kinds of repair and coal bills and feel that he is a worthy man to his employers. If your boilers are scaled or pitting, say so, and proceed at once to get them in a clean, healthy condition. Because if you do not say so, the boiler inspector and your fireman will. Some of your assistants will tell your neighbor, and your neighbor will tell others, and the public and your employer will eventually know that the boilers are dirty or in bad condition. The way to do is to get at it irrespective of any side issue or personality. Look for merits and see that you get them. Prepay the express on a jug of water to the **Dearborn Laboratories** at **Chicago,** and receive a copy of analysis of same, with a written diagnosis of your case and a letter giving you all the valuable information we can, and the actual cost of what it will require to clean your boilers and keep them clean.

All of this will be done free of charge, and optional with you whether you order or not.

DEARBORN DRUG AND CHEMICAL WORKS,

Manufacturing and Analytical Chemists.

CHICAGO.

Analyzers of Everything. ❋ **Makers of Boiler Compounds.**

WILLIAM H. EDGAR, President.

OFFICES:	WORKS:
29, 30, 31, 32 and 33 Rialto.	**2325-27-29 La Salle Street.**
Telephone: No. 3935 Main.	Telephone: No. 1130 South.

THE

MONON

Is the Best Route between

Chicago, Indianapolis, Cincinnati, Louisville and the South.

SOLID VESTIBULED TRAINS DAILY.

CITY TICKET OFFICE,

232 CLARK ST., CHICAGO.

W. H. McDOEL, Gen'l Manager. FRANK J. REED, Gen'l Pass. Agent.

"BIG FOUR"

THREE GREAT TRAINS.

"KNICKERBOCKER SPECIAL"
BETWEEN
ST. LOUIS, INDIANAPOLIS, CLEVELAND, CINCINNATI, NEW YORK AND BOSTON.

"SOUTHWESTERN LIMITED"
BETWEEN
CINCINNATI, COLUMBUS, CLEVELAND, NEW YORK AND BOSTON.

"WHITE CITY SPECIAL"
BETWEEN
CINCINNATI, INDIANAPOLIS AND CHICAGO.

E. O. McCORMICK, Pass. Traffic Mgr. WARREN J. LYNCH, Asst. Gen. Pass. & Tkt. Agt.

AN AMERICAN TRAVELER.

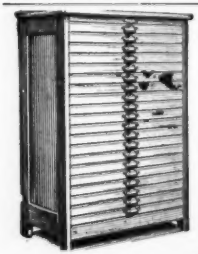
"I would not have believed that there could be such luxury in a thousand-mile journey as I found on the New York Central, between New York and Chicago," said a distinguished American who had spent the past fifteen years abroad. "There is nothing to equal it in all Europe."

For a copy of "The Luxury of Modern Railway Travel," send two 2-cent stamps to George H. Daniels, General Passenger Agent, Grand Central Station, New York.

ALL ARITHMETICAL PROBLEMS
solved rapidly and accurately by the Comptometer. Saves 60% of time and entirely relieves mental and nervous strain. Adapted to all commercial and scientific computation. Every office should have one.
Write for pamphlet.
FELT & TARRANT MFG. CO.,
52-56 ILLINOIS ST., CHICAGO.

For the busy man

THE ENGINEERING INDEX saves the most time and money—the only way to keep well up to date in engineering progress.



WELLS'S CUT CABINETS.

Advertisers often find it a problem how to take care of their valuable wood cuts, fine half-tones and electrotypes for their ads, catalogues, etc.
Wells's Cabinets, being *dust tight,* afford the best protection. They allow of good classification, thus saving time and trouble. ***Send for Circular.***

HEBER WELLS,
Corner ANN and WILLIAM STREETS, NEW YORK.

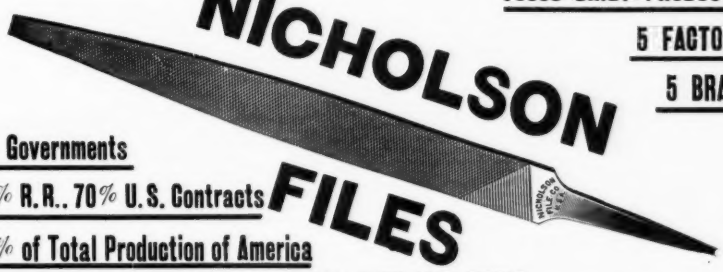
Plea e mention The Engineering Magazine when you write.

76800 DAILY PRODUCTION

5 FACTORIES

5 BRANDS

NICHOLSON FILES



16 Governments

85% R.R., 70% U.S. Contracts

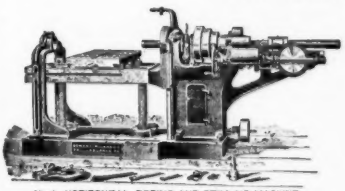
70% of Total Production of America

FOR SALE ALL OVER THE WORLD.

NICHOLSON FILE CO., Providence, R. I., U. S. A.

BEMENT, MILES & CO.,

PHILADELPHIA, PA., U. S. A.



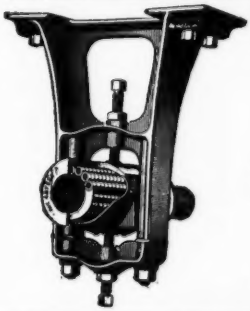
No. 1 HORIZONTAL BORING AND DRILLING MACHINE.

Manufacturers of METAL WORKING MACHINE TOOLS.

Lathes, Planing Machines, Shaping Machines, Slotting Machines, Milling Machines, Drilling Machines, Vertical, Multiple and Radial; Boring Machines, Vertical and Horizontal: Punching and Shearing Machines, Plate Bending Machines.

Steam Hammers, Steam and Hydraulic Riveting Machines, &c.

London.—C. W. Burton, Griffiths & Co., Ludgate Square, Ludgate Hill. Paris.—Fenwick Freres & Co., 21, Rue Martel. Berlin.—Schuchardt & Schutte, Spandauerstrasse, 59 and 61. Brussels.—Schuchardt & Schutte, 17, Rue de Fosse aux Loups. Vienna.—Schuchardt & Schutte, Breitegasse, 17. Stockholm.—E. Hirsch & Co., Vasagatan, 22-A.



If you are interested in

Roller Bearings, ask us where Hyatt Bearings have revolutionized olden time methods. Book free.

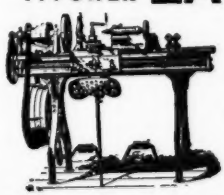
HYATT ROLLER BEARING CO.,

HARRISON, N. J., U. S. A.

133 LIBERTY ST., NEW YORK.

LONDON REPRESENTATIVE: ROBERT W. BLACKWELL, 39, Victoria St., Westminster, London, S. W.

FOOT... ..POWER **LATHES**



—FOR—

GUNSMITHS, TOOL MAKERS, EXPERIMENTAL AND REPAIR WORK.

9 to 13 in. Swing.

We can furnish our Lathes with stand-up treadle foot power or countershaft if desired.

W. F. & JNO. BARNES CO., 953 Ruby St.,

SEND FOR CTALOGUE. ROCKFORD, ILL

Oilless Bearings.

METALINE is a combination of anti-friction metals, solidified under hydraulic pressure into plugs and fitted into holes drilled to receive them on the bearing surface of bushings made of gun or composition metal.

Loose Pulleys fitted with these **Metalined Bushings run without oil, without danger from fire,** and are **very durable.** *Send for Circulars.*

North American Metaline Co.,
141 to 149 Third St., Long Island City, N. Y.

The Acme Machinery Co.,

Cor. Hamilton and St. Clair Sts., - Cleveland, Ohio.

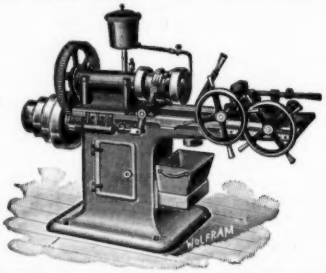
Manufacturers of

Acme Bolt and Rivet Headers,

Acme Single, Double and Triple Automatic Bolt Cutters.

Cutting from 1-8 in. to 6 in. diam.

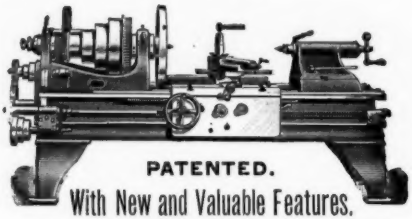
Also Separate Heads and Dies.



Manufacturers of Set, Cap and Machine Screws, Studs, etc.

THE ENGINEERING INDEX in this Magazine saves time for thousands of Engineers. Do you use it?

High Class Engine Lathes.



PATENTED.

With New and Valuable Features.

MADE ONLY BY

THE BRADFORD MILL CO., CINCINNATI, OHIO, U. S. A.

Charles Churchill & Co., Ltd., London and Birmingham.
Schuchardt & Schutte, Berlin, Vienna, Brussels, Stockholm.
Adhpe. Janssens, Paris, France.
The E. A. Kinsey Co., Cincinnati, Ohio.
J. A. Fay & Egan Co., Chicago, Ills.
J. W. Wright & Co., St. Louis, Mo.
Pacific Tool & Supply Co., San Francisco, Cal.
"Philadelphia Bourse," Philadelphia, Pa.

THE ENGINEERING INDEX.

A **new feature** of THE ENGINEERING INDEX is its publication separate from THE ENGINEERING MAGAZINE, printed on one side of the paper only. The idea is to better adapt it to Card-Index purposes.

Thus, to keep a permanent index to papers of interest that have been read before engineering societies, published in leading journals, etc., it is only necessary to cut out the items desired, paste them singly on cards and add each month's items, as they appear, to the preceding ones. The Index is already arranged alphabetically and classified in a manner enabling a quick finding of all articles published anywhere on any particular subject.

It will be seen that this is indispensable in every engineering library—private, associate, or public—as it is a complete alphabetical index to the contents of about 200 of the leading engineering and technical journals of the world.

It may be abridged or used complete, according to the needs of the user, so engineers will find it invaluable for private use in indexing the technical papers they subscribe for, or for indexing articles in any particular branch of engineering.

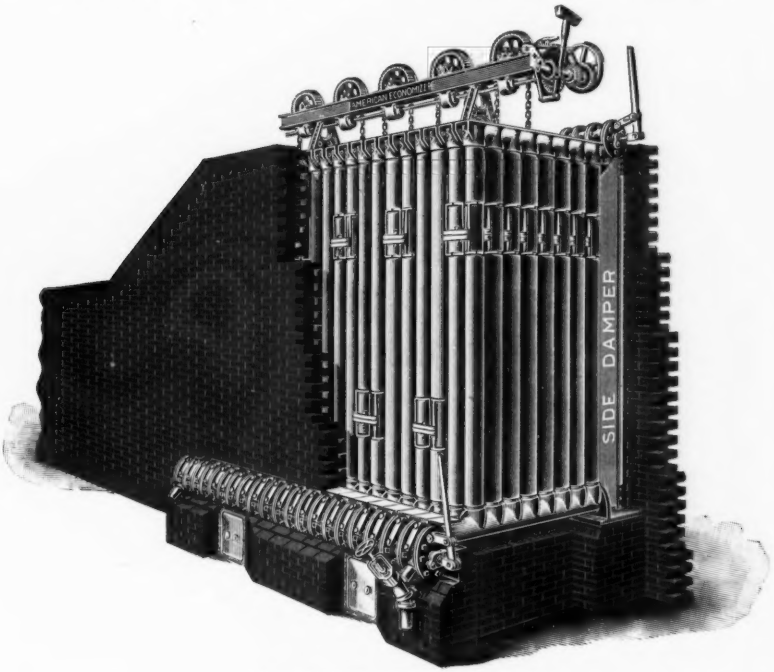
Subscription price, $1 a year; to subscribers for THE ENGINEERING MAGAZINE, 50 cents.

THE ENGINEERING MAGAZINE,

120 Liberty Street, New York.

THE AMERICAN FUEL ECONOMIZER,

BURPEE'S PATENTS. **BROOMELL'S PATENTS.**



BOILER REPAIRS.

HAVE you ever investigated the cause of boilers requiring such frequent and costly repairs? Why does your boiler get to leaking around the tubes or at the seams? Did you ever have the pleasant experience of shutting down at the time when you could least afford it, to put a new sheet on a boiler that "Bulged Down."

It costs money and valuable time to cut out tubes and put new ones in. What a nice thing it is to have inspectors report a head cracked between the tubes and order a new one in.

All of these troubles and many more are caused by feeding boilers with cold water; water full of grease from exhaust heaters or from scale formed from water that has not been heated sufficiently to purify it.

What the remedy is? Why feed your boilers with water way above the *boiling point.* How to get such water? why by using an **AMERICAN FUEL ECONOMIZER,** which will heat the water from heat otherwise wasted at the smoke chimney.

BROOMELL, SCHMIDT & CO., Limited,

MANUFACTURERS, YORK, PA.

Please mention The Engineering Magazine when you write.

THE ENGINEERING INDEX

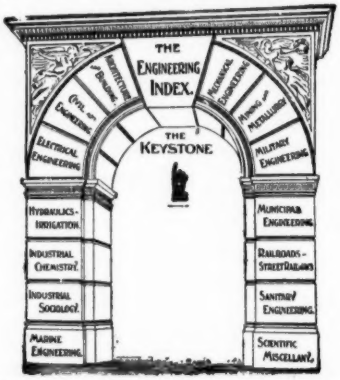
VOLUME II—1892 TO 1896

Handsomely Bound in Cloth—474 Pages—Price $4.00

TO THE PUBLIC:

Agreeable to a contract with the ASSOCIATION OF ENGINEERING SOCIETIES, we take pleasure in announcing Volume II of THE ENGINEERING INDEX, as above indicated. The work may be fairly described as a complete Handbook and Index to everything of value in all the rich and varied engineering literature of the four years from January 1, 1892, to January 1, 1896.

It is indispensable in every engineering library—private, associate or public—which pretends to be complete.



It is priceless to the man who knows the money-value of posting himself upon past practice before giving an expert opinion.

FROM THE PREFACE:

The material composing this volume has appeared in the monthly numbers of the *Journal of the Association of Engineering Societies* during the past four years, and it has been wholly prepared by technical experts, associated with the undersigned. The object kept continuously in view in the preparation of these notes has been to put in as small a space as possible such short descriptions of the scope and general character of the articles indexed as to enable one in search of information on a particular subject to decide whether or not it would be worth his while to obtain or consult the original article, paper, or report.

* * * * *

Since the elaborate index published in *The Engineering Magazine* has contained the characteristic descriptive notes which have made the index of the *Journal of the Association of Engineering Societies* so unique and so valuable, the Board of Managers of that journal have decided that it is no longer necessary for them to maintain this department. They therefore ceased to publish such index notes on January 1, 1896, and they cordially recommend their readers to become subscribers for *The Engineering Magazine* in order that the editor of that journal may feel justified in incurring the great additional expense of this department.

J. B. JOHNSON,
Chairman of Board of Managers,
Association of Engineering Societies.

Mailed to any Address on receipt of price.

THE ENGINEERING MAGAZINE
120-122 LIBERTY ST., NEW YORK

HOBSON, SEAMAN & COMPANY,

SUCCESSORS TO

FRANCIS HOBSON & SON,

DON STEEL WORKS, AND HOYLE STREET WORKS, SHEFFIELD,

SOLE MAKERS OF

HOBSON'S CHOICE STEELS,

For the Finest Classes of Tools and Needle Wire.

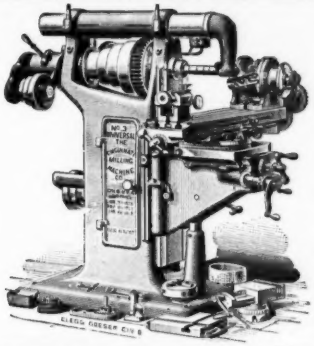
BRIGHT DRILL RODS—None more Accurately Drawn.

American Warehouse, 97 JOHN STREET, NEW YORK.

CHAS. HUGILL—Agent.

JESSOP'S STEEL FOR TOOLS, DRILLS, ALL KINDS IN STOCK. DIES, SAWS, &c. GOLD MEDAL, PARIS, 1889. HIGHEST AWARD, CHICAGO. CHIEF AMERICAN OFFICE, 91 JOHN ST. NEW YORK.

WILLIAM JESSOP & SONS, L'D. MANUFACTORY, SHEFFIELD, ENGLAND. W. F. WAGNER, GEN. MG'R.



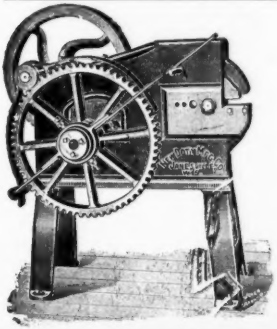
You Ought Not Buy

a miller until you know why "The Cincinnati" is so popular. Not only beautiful in appearance but a bigger producer of good results than any other miller you ever used. An investigation costs nothing but may save you much.

Yours for good millers,

THE CINCINNATI MILLING MACHINE CO.,

CINCINNATI, O., U. S. A.



Punching and Shearing Machinery.

HAND AND BELT POWER.

ALL SIZES.

NEW DOTY MFG. CO.,

JANESVILLE, WIS.,

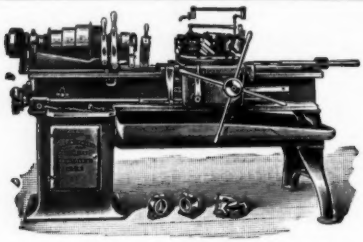
U. S. A.

REG. TRADE MARKS.

"Phosphor Bronze"

DELTA

THE PHOSPHOR BRONZE SMELTING CO. LIMITED,
2200 WASHINGTON AVE., PHILADELPHIA.
"ELEPHANT BRAND PHOSPHOR-BRONZE"
INGOTS, CASTINGS, WIRE, RODS, SHEETS, ETC.
— DELTA METAL —
CASTINGS, STAMPINGS AND FORGINGS
ORIGINAL AND SOLE MAKERS IN THE U.S.



THE FLAT TURRET LATHE,

Does Lathe work accurately up to 2" diameter by 24" long. . . .

JONES & LAMSON MACHINE CO.,

SPRINGFIELD, VT., U. S. A.

Main Office and Works: Springfield, Vermont, U. S. A. A. B. C. and Lieber's Codes Used.

ENGLISH OFFICES:
Room 6, Exchange Building, Stephenson's Place, Birmingham. G. H. POND, Manager.
—AND—
26, Pall Mall, Manchester, in charge of HENRY KELLEY & CO.

GERMANY, BELGIUM, HOLLAND, SWITZERLAND AND AUSTRIA HUNGARY:
M. Koyemann, Charlottenstrasse 112, Düsseldorf, Germany.

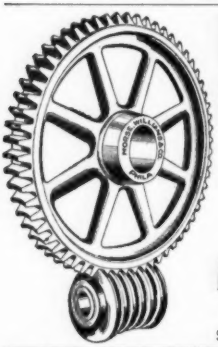
WOOD WORKING MACHINERY
FOR
Machinery Manufacturers.

Pattern Makers Machinery and Machinery for Boxing and Crating Rooms.

Prices and Particulars Furnished on Application.

J. A. FAY & CO.,

271-291 W. Front St., Cincinnati, O.



HINDLEY WORM GEARING

saves power and gives greatest efficiency in operation.

MADE BY
Morse, Williams & Co.
PHILADELPHIA, PA.
Send for descriptive circular.

BEVEL GEARS

Cut Theoretically Correct.

Special facilities for cutting worm wheels.

HUGO BILGRAM,
MACHINIST,
440 N. 12th St., Philadelphia, Pa.

THE CLONBROCK STEAM BOILER COMPANY,

BROOKLYN, N. Y.

Manufacturers of the

Morrin "Climax" and "Compound" Safety Water Tube Boilers.

Built in Units of 50 to 1000 H. P.

Also Builders of Smoke Stacks, Tanks, etc., and all classes of Iron Work.

Specifications, drawings and prices furnished on application.
Send for Catalogue of Climax and Compound

Please mention The Engineering Magazine when you write.

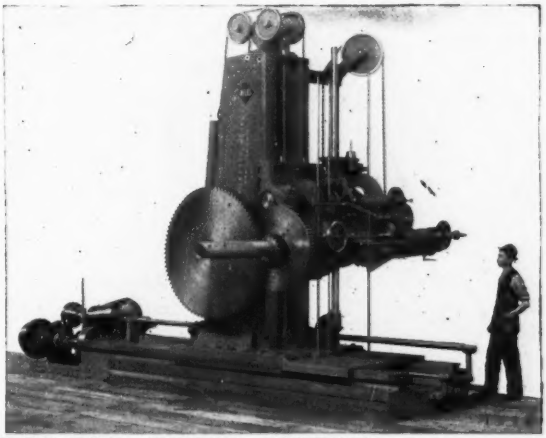
This is Only One of Many Different Sizes of these Machines that we build.

Why Do You Not Save the Handling of Heavy Pieces?

•

All Types and Sizes of Labor-Saving Machinery.

•



•

Patterns for over 300 Different Machines.

—

Write for full Description.

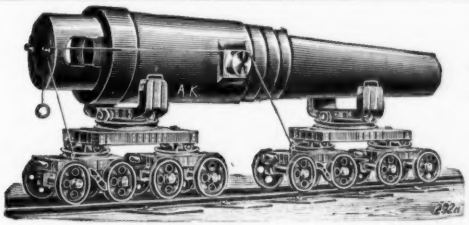
•

THE NILES TOOL WORKS COMPANY, Engineers and Builders,

Main Office and Works HAMILTON, OHIO.

BRANCHES:

St. Louis; London, S. W., 39 Victoria St.; New York; Philadelphia; Boston; Chicago; Pittsburg.



ARTHUR KOPPEL,

MANUFACTURER OF

NARROW GAUGE RAILWAY MATERIALS, ROLLING STOCK, PORTABLE TRACK, Etc.

EXPORT WORK A SPECIALTY.

Send for Catalogues and Estimates.

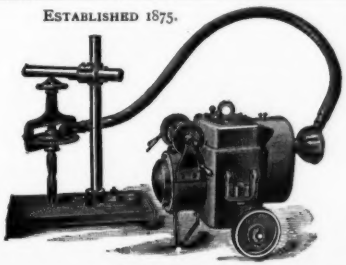
Exporter of American Machinery

OF EVERY DESCRIPTION.

68 Broad Street, New York.

Consult The Engineering Index; page 1041.

ESTABLISHED 1875.



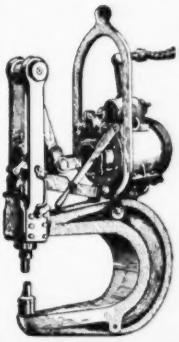
.....COMBINATION OF.....

Stow Flexible Shaft and Iron Clad Electric Motor.

Practically dust and water-proof For Portable Drilling, Tapping, Reaming, Emery Grinding, etc. Write for Catalogue and prices.

STOW MFG. CO., BINGHAMTON, N.Y. General European Ag'ts, Selig, Sonnenthal & Co., 85 Queen Victoria St., London, England

PNEUMATIC



Riveting Machines

For Bridge and Structural, Boiler and Tank Work.

MANUFACTURED BY

CHESTER B. ALBREE, IRON WORKS

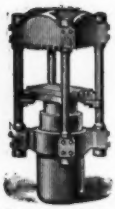
28 Market St., Allegheny, Pa.

Catalogue on Application.

Please mention The Engineering Mag. ine when you write.

THE WATSON-STILLMAN CO.,

204-210 EAST 43d STREET,
NEW YORK CITY.



Forging Press.

HYDRAULIC PRESSES.

Jacks. Punches.

Plain Press.

Curb Press.

SEND FOR CATALOGUE 5.

OBERLIN SMITH, Pres. and Mech. Engineer. FRED F. SMITH, Sec'y and Treas.

FERRACUTE MACHINE CO.,

Bridgeton, New Jersey, U. S. A.,

MANUFACTURERS OF

PRESSES AND DIES FOR BAR AND SHEET METALS.

Special Machinery for Mints, Hardware, Bicycle and Electrical Factories, Etc.

I am much pleased with THE ENGINEERING MAGAZINE. I consider it one of the most valuable publications for general information on engineering topics.

G. WILBUR HUHLEY, Supt.,
Louisville Electric Light Company,
Louisville, Ky.

E. W. BLISS CO.

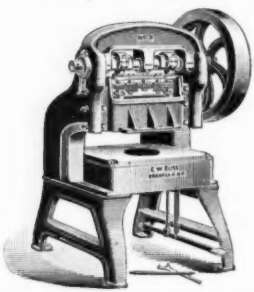
20 JOHN ST., BROOKLYN, N. Y.

Western Office: 96 W. Washington St., Chicago, Ill.

DESIGNERS AND BUILDERS OF

PRESSES, DIES, DROP HAMMERS, SHEARS and SPECIAL MACH'Y.

Correspondence Solicited. . . .



"Bliss" No. 2½ Overhanging Double Crank Press, Pat'd.

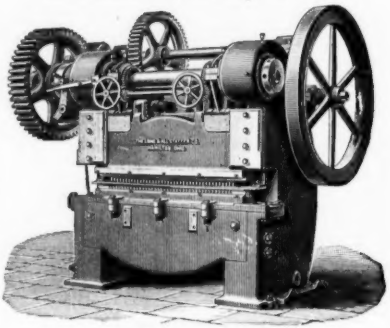
OWNERS OF THE STILES & PARKER PRESS CO.

BICYCLE, ELECTRICAL AND OTHER SHEET-METAL WORKING TOOLS.

THE

LONG & ALLSTATTER CO.,

HAMILTON, OHIO, U. S. A.



Multiple Punch.

Punching and Shearing Machinery,
Automatic Spacing Tables,
Drop and Helve Hammers,
Bending and Forming and Tire Welding Machines.

Please mention The Engineering Magazine when you write.

Forsyth's Patent

TRADE
GUTTA-BALATA
MARK.

Belting

Patented July 10, 1888,

is seamless, and, therefore, has no external seam to open or come apart.
Can be run with either side next to the pulley.
Has its plies so firmly united that separation is almost impossible.
Will not deteriorate with reasonable age.
Is practically unaffected by oils or grease.
Does not slip if properly adjusted to the pulleys.
Never requires any dressing.
Will stretch the least of any belt made.
Can be laced and spliced in the same manner as other belts.
Is very durable.
Will do hard and severe work successfully, and lots of it.
Will stand more abuse than any other belt.
Will give satisfaction where other belts have failed.
The list prices of Gutta-Balata Belting are the same as for regular rubber belting.

MANUFACTURED BY

BOSTON BELTING CO.

JAMES BENNETT FORSYTH, Mfg. Agt. and Gen. Mgr.

High Grade Rubber Goods.
Belting, Hose, Packing, Valves, Etc.

BOSTON,	NEW YORK,	BUFFALO,	CHICAGO,	SAN FRANCISCO,
256 Devonshire St.	100 Reade St.	90 Pearl St.	109 Madison St.	24 Fremont St.

THE OHIO PIPE CO.

COLUMBUS, OHIO.

CAST IRON PIPE OF ALL KINDS.

LOCOMOTIVE AND CAR CASTINGS.

THE McNEAL PIPE AND FOUNDRY CO.,

BURLINGTON, N. J.

MANUFACTURERS OF

CAST IRON PIPE.

Large Cylinders. Flange Pipe. General Foundry Work.

PHILADELPHIA OFFICE: Land Title Building, Broad and Chestnut Streets, Philadelphia, Pa.

THE

CHICAGO FLEXIBLE SHAFT CO.

MANUFACTURERS OF

FLEXIBLE SHAFTS under an **IMPROVED PROCESS,** insuring great strength and increased durability.

Warranted the Best.

Superior Shafts for all purposes. Also special and standard *Tools* and *Appliances.*

We now make

Wire Scratch Brushes

for use with the Flexible Shaft that are giving complete satisfaction.

SEND FOR CATALOGUE.

CHICAGO FLEXIBLE SHAFT CO.,

Nos. 158-160 HURON STREET, CHICAGO, ILL.

European Agents, Chas. Churchill & Co., 9-15 Leonard St., London, E. C.

We pay for copies of this magazine returned to us as follows:

May, 1891, . . $1.00
July, 1891, . . .50 } In cash or renewal.

We also credit one month's subscription for each of the following issues of the "Engineering Magazine," returned to us, viz.:

August, September, October and November, . . . 1891.
May, October and December, ... 1892.
April, ... 1894.
January, February, April, July and December, . 1895.
February and March, . 1896.

THE ENGINEERING MAGAZINE,
120-122 Liberty St., New York.

DROP FORGINGS

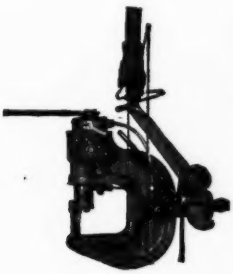
FROM MODEL OR DRAWING.

STRIEBY & FOOTE CO.,

301 OGDEN ST., NEWARK, N. J.

I place a high value on your Magazine and your system in connection with the papers bearing on all matters of great interest to those who are anxious to keep themselves posted to date. M. P. ELLIOTT, Pittsburg Plate Glass Co., Kokomo, Ind.

Please mention The Engineering Magazine when you write.



HYDRAULIC

Send for Pamphlet.

Riveters—Fixed and Portable.
Punches, Shears, Presses and Lifts.
Traveling and Jib Cranes.

Mathews' Fire Hyd-ants,
Eddy Valves,
Valve Indicator Posts.

Cast Iron Pipe

R. D. WOOD & CO., ENGINEERS, IRON FOUNDERS, MACHINISTS,

400 Chestnut St., PHILADELPHIA, PA.

THE CARBORUNDUM CO. · NIAGARA FALLS, N.Y.

CARBORUNDUM

REPLACING

Emery in Grinding and Polishing. Ferro-Silicon in Steel Making.

THE LATEST AND BEST—SEND FOR CATALOGUE AND PRICES.

Carbide of Silicon. SiC

ESTABLISHED 1848.

TOOLS

LARGE AND SMALL

HAMMACHER, SCHLEMMER & CO.,

209 BOWERY, NEW YORK.

CORRESPONDENCE SOLICITED.

The Tool Catalogue

could justly be called an encyclopedia of tools; it is a book that every mechanical engineer or person interested in tools, supplies or machinery should possess. The book is 10½ x 7½ in., contains 710 pages and over 3000 illustrations. Handsomely bound in cloth, sent express paid on receipt of $1.00. Money paid for catalogue is refunded with the first purchase amounting to $10.00 or over. Discount sheet with each book.

MONTGOMERY & COMPANY,

THE TOOL DEALERS, - - - 105 Fulton St., New York City.

LEVIATHAN BELTING.

Tested under the hardest possible conditions and proved by years of service to be the best possible belt

For Heavy Driving of all Kinds.

Proof against Heat, Steam and Water.

Strength, Durability, and Traction Power Unequalled.

SOLE MANUFACTURERS,

MAIN BELTING CO.,

1219-1235 Carpenter St., PHILADELPHIA.
55 & 57 Market St., CHICAGO.
120 Pearl St., - - BOSTON.

Send for price-lists and samples

Stop that Noise!

New Process Raw Hide Pinions are noiseless, cleanly and durable. Have stood the test of time and are endorsed by leading machinery manufacturers everywhere.

The New Process Raw Hide Co.,

Patentees and Sole Manufacturers,

SYRACUSE, N. Y., U. S. A.

Charles Churchill & Co., Ltd.

LONDON AND BIRMINGHAM, ENGLAND, AND GLASGOW, SCOTLAND.

ESTABLISHED 1865.

DEAL EXCLUSIVELY IN

AMERICAN MACHINE TOOLS

AND

REPRESENT A LARGE NUMBER

OF THE BEST KNOWN AMERICAN

MACHINE TOOL BUILDERS.

(SEE ADVERTISING COLUMNS OF THIS MAGAZINE ALSO "AMERICAN MACHINIST.")

LARGE SHOW ROOMS - - LARGE STOCK

INTIMATE RELATIONS WITH ALL THE LEADING

.....BUYERS IN ENGLAND.....

IN EVERY CLASS OF ENGINEERING OR ALLIED TRADES.

MANUFACTURERS DESIRING TO INTRODUCE NEW TOOLS SHOULD ADDRESS CORRESPONDENCE TO

9 to 15 LEONARD STREET, LONDON, E. C.

MAY 1891.

For each copy of the May, 1891, number of this magazine returned to us in good condition we will pay $1.00 in cash or exchange copies.

THE ENGINEERING MAGAZINE, 120-122 Liberty St., N. Y.

No. 3 UNIVERSAL GRINDER.
12" Swing, 42" between Centers.

Grinding • Machines,

PLAIN and UNIVERSAL.

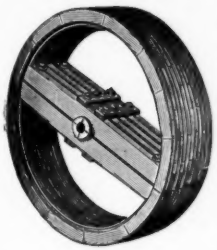
8 Sizes Manufactured by

LANDIS TOOL CO.,

WAYNESBORO, PA.

N. Y. Office, 126 Liberty St.
WALTER H. FOSTER, Mgr.
HILL, CLARKE & CO., Agts., Boston and Chicago.

"The Reeves" Wood Split Pulley,



with interchangeable bushing system for belt power transmission.

Lighter than an iron pulley. Stronger than a steel pulley. Each pulley will fit thirty-five sizes of shaft. No set screws. No key-way. Complete stocks carried in every jobbing center in the United States. Also:

CHAS. CHURCHILL & Co., 9 to 15 Leonard St., London, Eng.
SCHUCHARDT & SCHUTTE, Berlin, Brussels, Milan
FENWICK FRERES & Co., 21 Rue Martel, Paris, France.
WHITE, CHILD & BENEY, Vienna, Austria.

REEVES PULLEY CO., Columbus, Ind., U. S. A.,

SEND FOR CATALOGUE. **MANUFACTURERS.**

Gilbert Wood Split Pulleys.

Made in sizes from 3 in. to 24 ft. in diameter.

EVERY PULLEY WARRANTED.

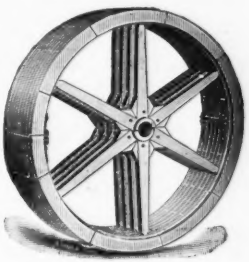
SAGINAW MANUFACTURING COMPANY,

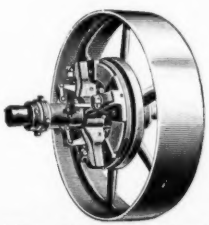
GENERAL OFFICES AND WORKS, SAGINAW, MICH.

Cable Address: ENGRAVE, N. Y. A. B. C. Code, 4th Edition.

NEW YORK BRANCH: **44 DEY STREET.**

AGENCIES IN ALL PRINCIPAL CITIES. Telephone, 187 Cortlandt.





Thousands of Frisbie Friction Clutches

- - ARE IN USE - -

All Over This Country.

Ask for our Friction Department Catalogue.

The Eastern Machinery Co., • • • New Haven, Conn.

Builders of the Standard

Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

"Direct Current 'Engine-Type' Generator."

Direct-Connected Generators.

New York, Atlanta, Austin, Boston, Buffalo, Chicago, Cincinnati, Philadelphia, St. Louis, San Francisco, Syracuse, Tacoma. Denver, Mountain Electric Co. Ahearn & Soper. Ottawa, Canada. G. & O. Braniff & Co., City of Mexico. Westinghouse Electric Co., Ltd., 32 Victoria St, London.

FORT WAYNE ELECTRIC CORPORATION,

FORT WAYNE, IND.

Apparatus for Arc, Direct Current and Alternating Incandescent Lighting and Power Transmission.

BRANCH OFFICES:

NEW YORK CITY, 115 Broadway.
CHICAGO, ILL., 621-625 Marquette Building.
PHILADELPHIA, PA., 104 The Bourse.
BOSTON, MASS., 17 Federal Street.
ROCHESTER, N. Y., Powers Building.
SAN FRANCISCO, CAL., 18 Second Street.
PITTSBURGH, PA., 918 Park Building.
NEW ORLEANS, LA., 715 Perdido Street.
OMAHA, NEB., 1403 Farnam Street.
ST. PAUL, MINN., 207 Newspaper Row.
CINCINNATI, OHIO, 402 Neave Building.
ST. LOUIS, MO., 321 Security Building.
ATLANTA, GA., 25 Marietta Street.
EXPORT DEPARTMENT, 115 Broadway, N. Y. City.

KEYSTONE ELECTRIC COMPANY,

ERIE. CHICAGO. NEW YORK. BOSTON. PHILADELPHIA. NEW ORLEANS. ST. LOUIS. OMAHA. WELLSVILLE, O.

Type G & H MOTORS AND GENERATORS, Open and Enclosed.

Adapted to Ceiling, Wall and Floor.
Geared or Direct Connected to Shafting, Machines, Machine Tools, etc.

H. B. COHO & COMPANY,
30 CORTLANDT ST., NEW YORK.
Motors and Generators,
Direct and Alternating Current, New and Second Hand.

ARTESIAN WELLS
AND WATER SUPPLY.
Wells sunk in Earth or Rock any depth.
Soundings made for Foundations or Water.
Hot Air Pumping Engines and Wind Mills Supplied.
GOLE BROTHERS, Contractors,
102 Fulton Street, New York

You are maintaining and even exceeding the high standard which makes THE ENGINEERING MAGAZINE unique among technical publications.
RICHARD A. WHITE, Auditor of Disbursements,
N. Y. C. & H. R. R. R.

Please mention The Engineering Magazine when you write.

LUNDELL
POWER MOTORS

Slow, Medium and High Speed for all Requirements.

Geared or Direct-Connected.

SPRAGUE ELECTRIC COMPANY,

NEW YORK. ∴ ∴ CHICAGO. ∴ ∴ LONDON.

MARQUETTE BUILDING.

THE TRIUMPH ELECTRIC CO.,

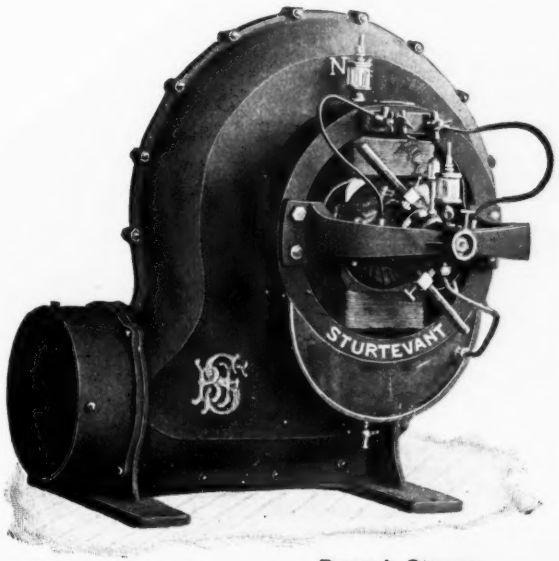
CINCINNATI, O.

COMPLETE EQUIPMENTS for the Economical Distribution of LIGHT and POWER.

Arc and Incandescent Lights and Power Supplied from *One Machine*.

MINING, RAILWAY, and CENTRAL-STATION EQUIPMENTS.

Marine Plants. Offices in all Large Cities in the United States. **Electric Elevators.**



THE

Sturtevant Electric Fans.

WE MAKE THE FAN AND MOTOR COMPLETE.

B. F. Sturtevant Co.

WORKS:

BOSTON, MASS.

Branch Stores:

Please mention The Engineering Magazine when you write.

William Sellers & Co. Incorp.

PHILADELPHIA, PENNA.

MODERN LABOR SAVING MACHINE TOOLS.

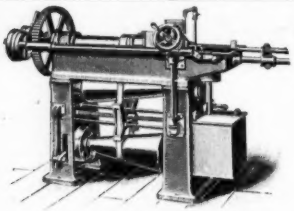
NOTE TO READERS.

Within the past few years the ENGINEERING MAGAZINE has discussed, very thoroughly, the subject of ECONOMICS OF AMERICAN MANUFACTURES from the theoretical point of view, and we have carefully considered the same subject from the practical standpoint. We are constructors of machine tools which are designed to economize hand labor and to produce accurate work.

The following is a partial list of our tools.

Boring Mills, Bending Rolls, Bolt Cutters, Cranes, Drilling Machines, Grinding Machines, Gear Cutting Machines, Tool Shaping and Sharpening Machines, Milling Machines, Punching Machines, Planing Machines, Riveting Machines, Slotting Machines, Shearing Machines, Steam Hammers, Mechanical Stokers, Testing Machines, Turn Tables, Wheel Presses.

PULLEYS, SHAFTING, INJECTORS, ETC., ETC., ETC.



No. 2 CUTTING OFF LATHE.

CUTTING OFF LATHES,

in four sizes, with automatic feed and stop motion, made with and without mechanism for automatically quickening the motion of the spindle as the cutting tool advances toward the center of the work. One man may attend two or more machines. 2 Spindle Centre Drilling and Reaming Machines.

MODEL MAKING, SPUR GEAR CUTTING, BEVEL GEAR MILLING, AND SHAFT AND SPINDLE DRILLING GIVEN SPECIAL ATTENTION. . . .

ASK FOR CATALOGUE E.

THE PRATT & WHITNEY CO.,

HARTFORD, CONN., U. S. A.

NEW YORK:-123 Liberty Street. BOSTON:-144 Pearl Street.

CHICAGO:-42 South Clinton Street.

LONDON, ENGLAND:-BUCK & HICKMAN, 280 Whitechapel Road.

PARIS, FRANCE:-FENWICK FRERES & CO., 21 Rue Martel.

THE ATLANTIC WORKS, EAST BOSTON

STATIONARY BOILERS — BUILDERS OF — PENSTOCKS, DIGESTERS TANKS, KIERS.

MACHINERY & PLATE-IRON WORK OF EVERY DESCRIPTION. ALSO STEAM YACHTS, MARINE ENGINES, & BOILERS, MARINE RAILWAY.

4 of these boilers will develop 8400 H. P.

THORNYCROFT WATER TUBE BOILERS.

450,000 Horse Power in use. Light, Durable and Efficient.

From its light weight and great efficiency, it is the best boiler to substitute for Scotch Boilers in large ships.

THORPE, PLATT & CO.,

67 Cedar Street, **New York City.**

Please mention The Engineering Magazine when you write.

Kyanized Lumber. If you are not familiar with the process and its uses, send a 2c. stamp for our beautifully illustrated pamphlet on "The Artificial Preservation of Timber." It will give you a great deal of information on the subject.

The process of Kyanizing has a test of more than fifty years of actual practice back of it. You cannot afford to neglect its use.

Write us and enquire about it. **OTIS ALLEN & SON, Lowell, Mass.**

THE McCabe No. 2 PARLOR DOOR HANGER...

MANUFACTURERS OF HANGERS

- - FOR - -

PARLOR DOORS,
BARN DOORS,
ELEVATOR DOORS,
ACCORDION DOORS,
SLIDING LADDERS.
OVERHEAD CARRYING.

THE McCABE HANGER MFG. CO..
532 West 22d Street, New York City.

BRIDGES BERLIN BUILDINGS

OUR CATALOGUE
OF THREE HUNDRED PAGES ILLUSTRATING AND DESCRIBING A LARGE NUMBER OF

BRIDGES
BUILDINGS
AND ROOFS

Designed and Built by us Is now ready and will be sent on application.

THE BERLIN IRON BRIDGE CO.
EAST BERLIN, CONN.

CENTRAL FIREPROOFING COMPANY

Manufacturers and Contractors for the Erection of

HOLLOW TILE and POROUS TERRA-COTTA

FIREPROOFING

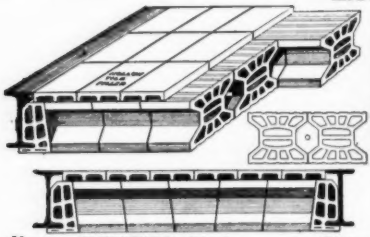
THE ONLY FIREPROOFING MATERIAL WHICH HAS STOOD THE TEST OF ACTUAL FIRES.

HENRY M. KEASBEY, *President.* 874 BROADWAY, New York.

CONTRACTS TAKEN IN ALL PARTS OF THE UNITED STATES OR CANADA.

HENRY MAURER & SON,

ESTABLISHED 1856.



MANUFACTURERS OF

FIRE-PROOF BUILDING MATERIAL

Of every description. Hollow Brick made of Clay for Flat Arches, Partitions, Furring, etc. Porous Terra-Cotta, Fire Brick, etc., etc.

Works, MAURER, N. J. Office and Depot, 420 EAST 23d ST., New York.

Send for 1897 Catalogues on "Fireproofing" and "Fire-Brick."

PITTSBURGH TERRA COTTA LUMBER CO.,

Manufacturers and Contractors for the Erection of

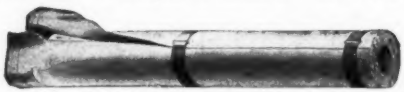
Porous and Dense Terra Cotta. FIRE PROOFING

Works: Pittsburgh, Pa. Washington, N. J. East Palestine, Ohio.

General Offices: Carnegie Building, Pittsburgh, Pa.

Eastern Office, Townsend Building, 25th St. and Broadway, New York.

ASBESTOS FIRE-FELT COVERINGS.



The Most Efficient and Durable Non-Conducting Coverings for Pipes and Boilers. FIRE-FELT Covering made in Cylindrical Sections for Pipes, Sheets for Boilers and other Large Surfaces. Does not sag from pipe. Will not powder. Is not affected by moisture or vibration.

H. W. JOHNS M'F'G CO.,

100 WILLIAM ST., NEW YORK.

Chicago. Philadelphia. Boston. Columbus. Detroit. Pittsburgh.

T. H. BROOKS & CO. CLEVELAND, O.

FLOOR & SIDEWALK LIGHTS. OF EVERY DESCRIPTION. SEND FOR CATALOGUE.

The Best Protective Coatings for Iron are

LAWRENCE'S PERMANENT PAINT FOR IRON AND STEEL

LAWRENCE'S ASPHALTIC BRIDGE CONSERVATIVE

IN THE USE OF THESE COATINGS THE BEST RESULTS ARE OBTAINED
PARTICULARS ON APPLICATION TO THE MAKERS

W. W. LAWRENCE & COMPANY
PITTSBURGH, PA.

The WINSLOW BROS. CO.,

ORNAMENTAL IRON WORK,

368-408 CARROLL AVENUE,

CHICAGO.

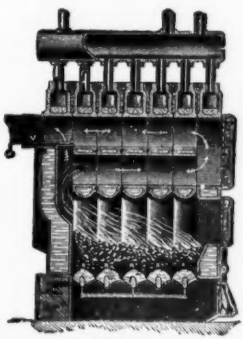
Ornamental Iron for Buildings ✠ Art Metal Work in Wrought and Cast Iron, Bronze, Brass and Aluminum ✠ Special Finishes in Bower-Barff, Bronze, Duplex Bronze, Galvanoplastic, Enamelling and Fire-Gilt ✠ Special Designs Submitted ✠

"I have n't time," you may say, "to read all the technical papers." It would be waste of time to try to read them all, for The Engineering Index places before you each month the gist of some 200 leading engineering journals of the world, and tells which of the hundreds of articles you ought to read.

If you don't happen to have access to a desired article, we furnish it.

See page 1041 this Magazine.

STEAM AND WATER HEATING APPARATUS



For Public Buildings, Residences, etc.

OUR SPECIALTIES. . . . .

Mercer, Mills, Gold and Cottage Steam and Water Heating Boilers. Adapted for Hard or Soft Coal and Wood Burning.

The Royal Union, Union, Champion and Imperial Water and Steam Radiators.

Gold's Pin Indirect Radiators for Steam or Water.

THE H. B. SMITH CO.,

133-135 Centre St., New York.

SEND FOR CIRCULAR.

FOUNDRY:
WESTFIELD, MASS.

Please mention The Engineering Magazine when you write.

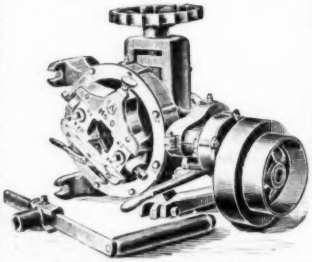
QUIMBY SCREW PUMPS, POWER PUMPS AND ELECTRIC PUMPS.

NO VALVES. NO PACKING. NO PULSATION.

Trade QUIMBY Mark.

WILLIAM E. QUIMBY,

Send for Catalogue. Washington Life Bldg., 86 Liberty St., New York.



Attach it to a bench or post.

Armstrong's No. 0 Threading Machine,

With Power Attachment.

Designed for threading the smaller sizes of pipe – iron or brass—and bolts. Works with great ease and rapidity. Has two speeds, one for pipe 1-8 to 1 inch; the other for pipe 1 1-4 to 2 inches, inclusive. You simply change crank from one to the other, as desired, and so get rid of turning a great many times on small pipe. Other attractive features.

Send for full particulars.

THE ARMSTRONG MFG. CO.,

139 CENTRE ST., NEW YORK. BRIDGEPORT, CONN.

STAMP SHOES.

STAMP DIES.

ADAMANTINE SHOES AND DIES

AND CHROME CAST STEEL

Cams, Tappets, Bosses, Roll Shells and Crusher Plates. Also, Rolled Parts for Huntington and other Mills.

These castings are extensively used in all the Mining States and Territories of North and South America. Guaranteed to prove better and cheaper than any others. Orders solicited subject to above conditions. When ordering send sketch with exact dimensions. Send for Illustrated Circular.

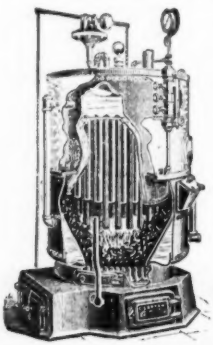
CHROME STEEL WORKS,

C. P. HAUGHIAN, President
F. E. CANDA, Vice-Pres't
C. J. CANDA, Secretary
J. G. DUNSCOMB, Treasurer

Kent Ave., Keap and Hooper Sts.,

BROOKLYN, N. Y.

The Gorton Soft Coal Boiler



is the only boiler that will burn soft coal, by coking it before it feeds down on the fire. This gives the greatest economy and reduces the cost of running this boiler below that of any other on the market. The FIRE-POT in the Gorton Soft Coal Boiler is so constructed that sufficient additional air is drawn through the fingered ring at the lower edge of the coking chambers, to ignite all the gases arising from the coking process, giving perfect combustion and preventing the deposit of soot and unconsumed carbon on the heating surface of the boiler, and making use of that part of the fuel which is wasted when soft coal is used in ordinary fire-pots.

Further information on application.

GORTON & LIDGERWOOD CO.,

96 Liberty Street, New York,

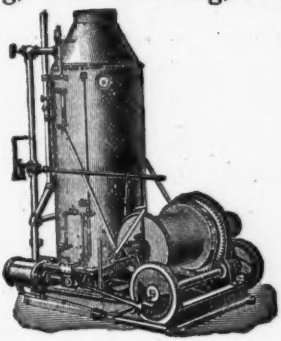
Old Colony Building, Chicago.

Please mention The Engineering Magazine when you write.

HOISTING MACHINERY

OF IMPROVED DESIGN AND CONSTRUCTION

For Mining, Quarrying, Coal Handling, Pile Driving, Bridge Building, Log Hauling, Cable-ways, and for General Contractors' use.



Improved Electric Hoists, single and double Patent Friction Drum, for general Hoisting and Mining Purposes.

Send for our new Catalogue A.
Correspondence Solicited.

LAMBERT HOISTING ENGINE CO.,

Salesrooms, 143 Liberty Street, New York. 117-123 Poinier St., Newark, N. J.
117 Main St., Cambridgeport, Mass.

GUILD & GARRISON,

Kent Ave. cor. South 10th Street.
Take Roosevelt, Grand or E. 23d Street Ferry from New York.

BROOKLYN, N. Y.

STEAM PUMPS.
VACUUM PUMPS.
FILTER-PRESS PUMPS.
DRY AIR COMPRESSORS.

VACUUM APPARATUS.
CONDENSERS.
AMMONIA PUMPS.
ACID BLOWERS, ETC.

MANUFACTURERS ADVERTISING.

350 MEDIUMS

Representing every trade and industry in the world.
Lowest rates, prompt service.

Manufacturers Advertising Bureau,

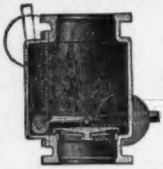
BENJ. R. WESTERN, Prop.
JOS. H. WILLIAMSON, Mangr.

(EST'D. 1879.)

NEW YORK.

Please mention The Engineering Magazine when you write.

PRINTED BY CLARK & ZUGALLA, N. Y.



Excelsior Straight-Way Back Pressure Valve.

This valve has no dash pots, springs, guides or complicated levers to get out of order. It is simple, reliable and well made. Never sticks, and can be relied upon at all times when using exhaust steam for heating; or when used as a relief, or free exhaust on a condensing plant, it has no equal. It is noiseless and free from any complicated attachments.

JENKINS BROTHERS, NEW YORK, PHILADELPHIA, BOSTON, CHICAGO.

SUPERIOR STEEL CASTINGS

FROM ½ OZ. TO 300 POUNDS.

Soft and Easily Machined. Smooth, Sharp, and True to Pattern. Machine parts, Fire Arms, Hydraulic and Ice Machines, also Castings to Harden, Etc., Etc.

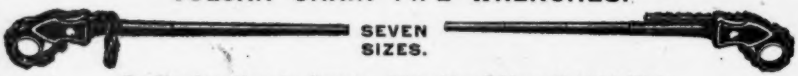
SEND FOR DESCRIPTIVE CIRCULAR.

STANLEY G. FLAGG & CO., Philadelphia, Pa. New York Office, 220 Broadway.

J. H. WILLIAMS & CO., DROP-FORGINGS,

9 to 31 Richards St., Brooklyn, New York, U. S. A.

VULCAN CHAIN PIPE WRENCHES.



SEVEN SIZES.

For Pipe from ⅛—12 in. diameter. With either Cable or Flat Link Chain.

DROP-FORGED WRENCHES OF EVERY KIND.

Send for Catalogue.

TRADE MARK W

EYE-BOLTS.

FINEST GOLF CLUB HEADS.

ORDNANCE AND BICYCLE FORGINGS A SPECIALTY.

PLANED BEVEL GEARS

MACHINE MOULDED GEARS.

Gears up to 12 Feet Diameter.

GLEASON TOOL CO.

Mfrs. LATHES and GEAR PLANERS,
4 Race St., Rochester, N. Y.

THE BRISTOL COMPANY,

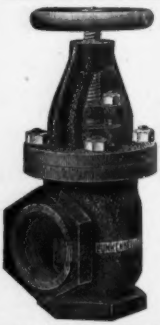
WATERBURY, CONN.

MANUFACTURERS OF

BRISTOL'S RECORDING INSTRUMENTS

Pressure Gauges, Vacuum Gauges, Thermometers, Ampere Meters, Volt Meters and Watt Meters. Make continuous Records Day and Night. Fully Guaranteed.

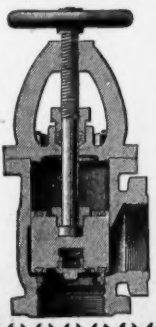
NEW YORK BRANCH, 121 LIBERTY ST.



LUNKENHEIMERS'

IRON BODY ANGLE BLOW-OFF VALVES

guaranteed for working pressures up to 250 lbs. All parts iron excepting stem, disc-locknut, disc-plug, seat ring of bronze. Reversible bearing faces in disc are filled with Babbitt metal. Durable in every way. Sizes 2, 2½ and 3 inches. Write for catalogue Specify Lunkenheimer's.



THE LUNKENHEIMER CO.,

CINCINNATI, OHIO, U. S. A.

NEW YORK: 26 CORTLANDT STREET.

LONDON: 35 GREAT DOVER STREET, S. E.